Materials Engineering in Product Design & Manufacture

Materials & Methods

February 1955

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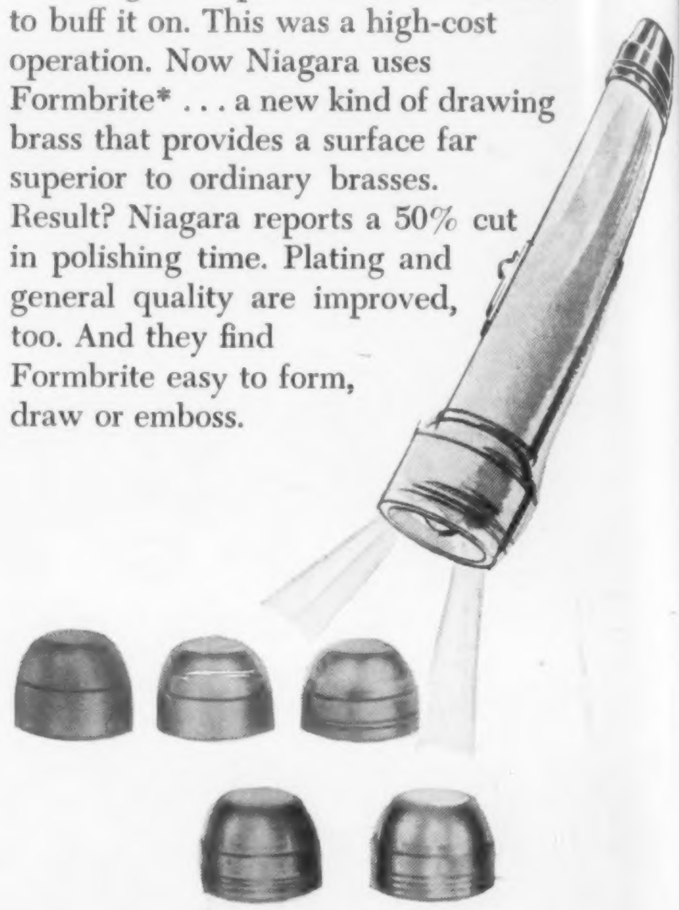
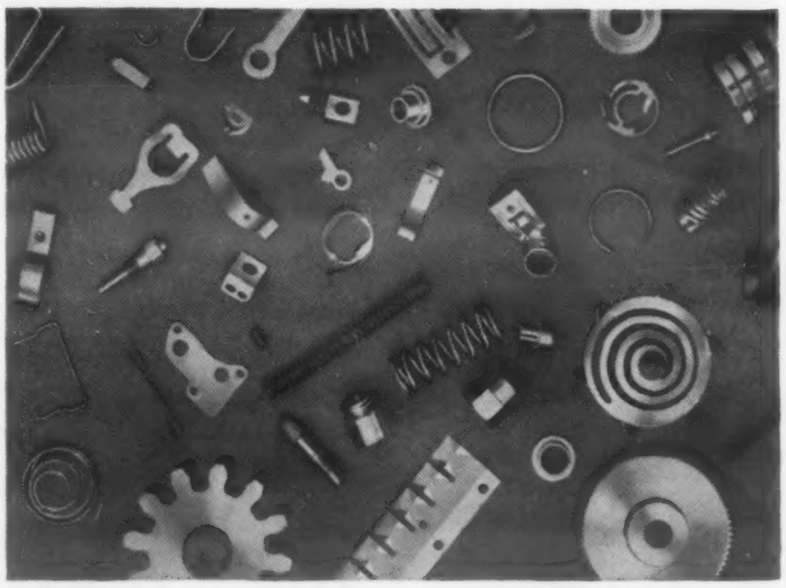
ANACONDA METALS AT WORK

The American Brass Company develops a new kind of brass that cuts polishing time 50% for one manufacturer and improves product appearance for another...makes bronzes that extend the life of many metal parts

Spotlight on high luster at low cost

The high luster on these brass flashlight end caps didn't come naturally. Niagar Searchlight Corp., Buffalo, N. Y., had to buff it on. This was a high-cost operation. Now Niagara uses Formbrite* . . . a new kind of drawing brass that provides a surface far superior to ordinary brasses. Result? Niagara reports a 50% cut in polishing time. Plating and general quality are improved, too. And they find Formbrite easy to form, draw or emboss.





Old age insurance...

It's easy to take out. All you do is specify *Duraflex,*** a group of new fine-grain phosphor bronzes. For components like those shown above, Anaconda's new type phosphor bronzes provide 30% greater endurance than other phosphor bronzes. *Duraflex* alloys are strong, tough and bear up under constant wear and flexing, periodic stress, fatigue and corrosion. They resist abrasion, conduct heat and electricity well and keep their high elasticity. *Duraflex* alloys are available at no increase in cost.

**Trade Mark

What's in a nameplate?

According to the Arlen Trophy Co., Brooklyn, N. Y., one of the largest trophy and premium manufacturers in the country, the *appearance* of a nameplate often means the difference between landing or losing a sale. But price is important, too. That's why Arlen now makes their nameplates out of Formbrite. It costs no more than ordinary brasses. Yet, because of its superfine grain structure, it polishes to a bright finish in half the time. Formbrite results in harder, stronger, springier, more scratch-resistant products, too.

5482 Rev.

Want more information?

Our Technical Department can give you a wealth of information on the properties and applications of Formbrite Drawing Brass and Duraflex Phosphor Bronze. Write to: *The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.*

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For more information, turn to Reader Service Card, Circle No. 464

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Materials & Methods.

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FEATURE ARTICLES

MATERIALS & METHODS MANUAL NO. 113

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MATERIALS & METHODS IS INDEXED REGULARLY IN THE ENGINEERING INDEX AND THE INDUSTRIAL ARTS INDEX

Materials BRIEFS

Skylight

Unpigmented glass reinforced plastics panels in the roof of truck trailers serve as skylights, facilitate loading and unloading operations. 75% of one company's trailer output has skylights.

More Light

A new plastics lamp to brighten up dim corners consists of an air-tight plastics bubble which is inflated like a toy balloon. The light lamp hangs from its electrical cord.

Water

It takes 42 gal of water to manufacture a pound of rubber. A pound of rayon requires 1000 gal.

Portable Lodge

The Crown Prince of Saudi Arabia has ordered a portable aluminum hunting lodge consisting of several complete buildings. It looks as if the days of silently folding tents are numbered for the Arabs.

Aluminum Anchor Chain

Mine sweepers for the Royal Canadian Navy have nonmagnetic anchor chains of 7075 aluminum alloy treated to T6 temper. Tests show the material achieved tensile strength of 77,000 psi.

Tape Capacitors

A self-adhesive tape capacitor for "Project Tinkertoy" electronic assemblies has its conducting surface sprayed on. Conductor is a formulation of silicone, silver flakes, and solvent. Dielectric layer of epoxide resins is also sprayed on tape.

Canned Bearings

A major manufacturer of needle bearings now ships them in evacuated food-type tin cans. Method eliminates preshipment lubrication and post shipment cleaning. A gallon can holds over 25,000 bearings.

(*Men of Materials on page 9*)

What's the Date of Your Last Calibration

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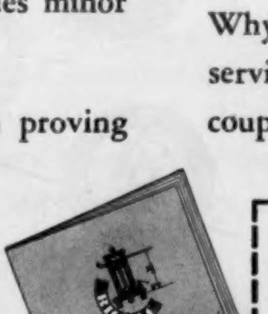

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Men of Materials...

their views
on development
and utilization
of engineering materials
in industry

Glenn G. Havens
President
Narmco, Inc.

A physicist by education, Dr. Havens has applied the general outlook of that science to current engineering problems. After an eight year stint with the research department of the U. S. Rubber Co. in Detroit, Dr. Havens moved west where he helped to pioneer adhesive bonding developments for Consolidated Vultee Aircraft. In 1944 he launched his own firm, National Research and Mfg. Co., known as Narmco. Initially producing a new type of bonding tape for aircraft, the company now produces many types of aircraft components and is concerned with adhesive bonding in many other branches of industry.

"Today it is literally true that the modern plane is glued together. But modern aircraft applications of structural adhesives were regarded as wholly impractical as recently as five years ago. Consider, for example, the fact that with one exception, the use of adhesives in aircraft before 1950 was confined chiefly to radomes and other fiberglass laminates. The one exception was the B-36, which utilized bonded magnesium and aluminum components to accommodate extreme vibrations and minimize weight penalties.

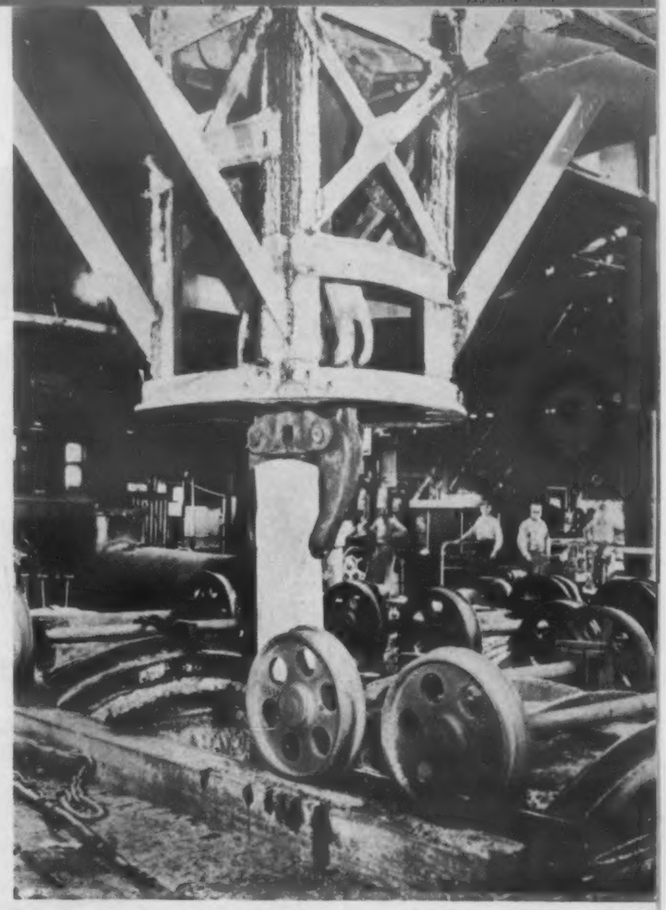
"Now, every major U. S. aircraft company is using adhesives in one form or another. In fact, it is impossible to build a modern high performance plane without structural adhesives; the need for non-welded and non-riveted components is greatly increased at sonic and near-sonic speeds; skin temperatures of several hundred degrees make it necessary to thermally insulate gasoline wing tanks from metal skins with nonmetallic sandwich-type construction; and high altitude performance requirements create the need for airframes that are lighter per unit of strength.

"The so-called sandwich type of construction, in which a lightweight core material is bonded between two thin skins has a structural efficiency ranging as high as 50% compared to about 10% for riveted and bonded constructions. This exceptional structural efficiency has sent every aircraft company into the field of adhesive bonding.

"The future will doubtless bring adhesives capable of performing at still higher temperatures, 700 F or more. These adhesives will be used to bond metal and nonmetal sheets, to bond fiber glass, to make core materials and to make sandwich-type constructions. In all likelihood, they will make the plane of tomorrow as revolutionary as those of today are by standards of a decade ago."

MATERIALS ENGINEERING **News Digest**

Sees Lower Titanium Price



4000-lb titanium ingot *is removed from soaking pit prior to rolling.*

Continued price reductions for titanium throughout 1955 are forecast by Thomas W. Lippert of the Titanium Metals Corp. of America. Mr. Lippert based his forecast on the increasing know-how in the titanium producing industry, and from the record of the past year.

In 1954, the price of sponge titanium was reduced from $5.00 per lb to $4.72 in April, and further reduced to $4.50 per lb in December. The prospect of further decreases in titanium cost will depend on the fast development and production pace set by the industry and on exploitation of current pilot operations which are expected to lead to full recycling of scrap metal.

The past year was marked by a drastic tightening of consumer specifications for finished forms of titanium, according to Mr. Lippert, but the limit of tightening these specifications has been reached, he believes. Growing experience with present specifications, which are stricter than any for other structural materials, will result in greater production and lower costs.

Production to double

There are still only two American producers of raw titanium sponge — Titanium Corp. of America and E. I. duPont de Nemours. These two producers achieved a ten tons per day rate of production in 1954. Total 1954 production is estimated by government agencies as 5250 tons, of which TMCA and DuPont contributed about 2500 tons each, and the balance coming from the Bureau of Mines and various pilot units. Imports from Japan for 1954 totaled 250 tons.

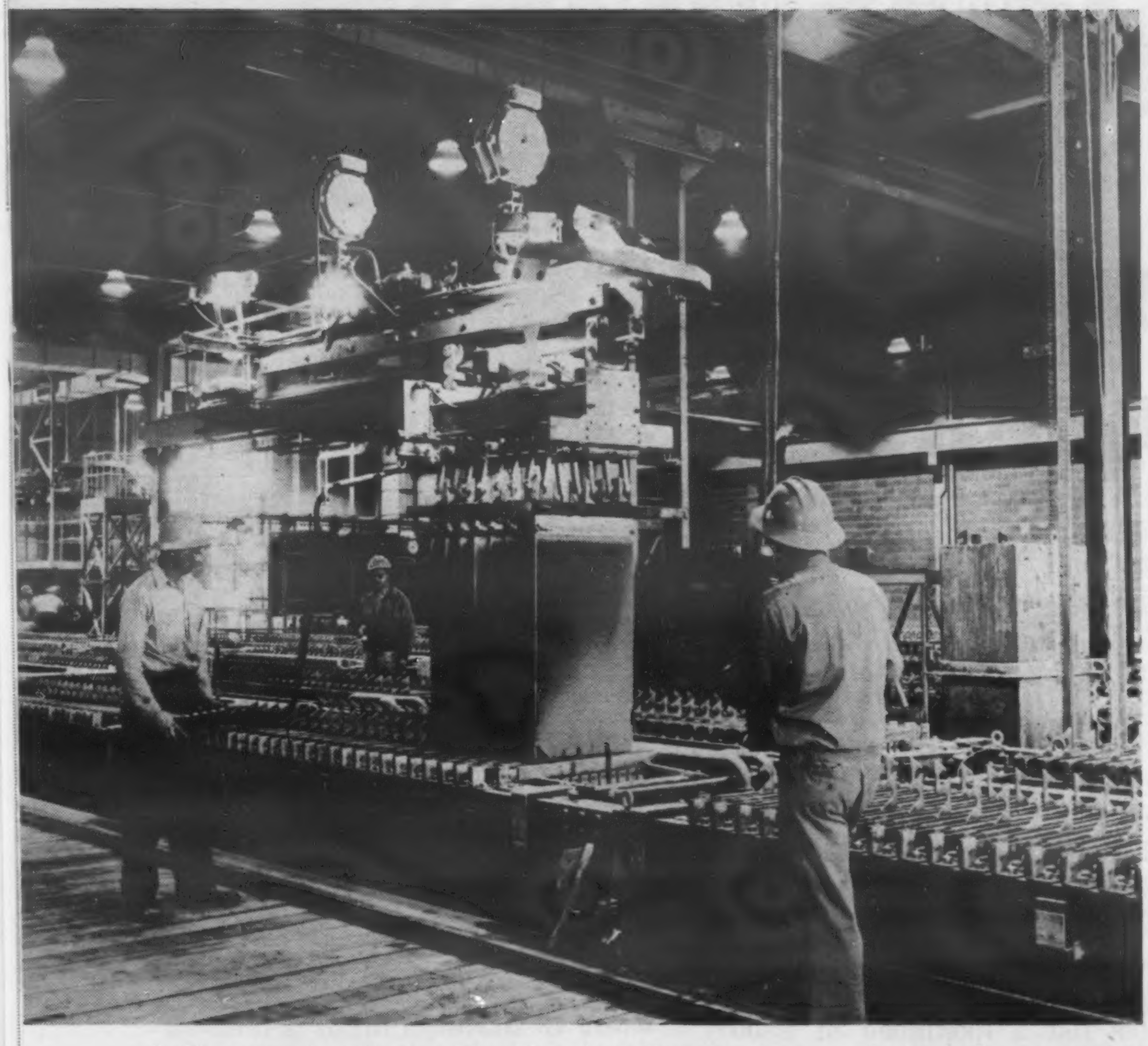
For the past five years, the production of titanium has approximately doubled each year, and some sources indicate a possible doubling again in 1955. This would provide a total output of slightly more than 10,000 tons. More conservative estimates list a likelihood of 8800 tons this year, and perhaps as much as 22,500 by 1957. Only one facility is certain to add to the 1955 production, and that is the new plant of Cramet, Inc., which is now building a 6000 ton unit. Dow Chemical will probably come in with pilot quantities of titanium from its 1800 ton per year plant now building, but will not approach full production until 1956. According to Mr. Lippert, the most significant new entry in the titanium producing field in 1954 was the Electro Metallurgical Co. division of Union Carbide and Carbon Corp., which contracted to produce 7500 tons per year by the sodium reduction process (*News Digest Nov. '54*). The plant will not be in production until late 1957, however.

Production techniques

On the technological front, no new or particularly significant technique for producing the sponge metal has made an appearance, although Horizons Titanium is building a small electrolytic pilot plant at Stamford, Conn. Electro-Metallurgical Co. and Imperial Chemical Industries have attracted considerable attention by reverting to a modification of the original method of using sodium to reduce the tetrachloride instead of the Kroll-magnesium reduction process.

The sharp increase in sponge production last year created a short term oversupply of the metal in the face of repeated government announcements that present and planned production facilities are insufficient to meet the requirements of the Air Force alone. Mr. Lippert said, "Actually, aircraft manufacturers can't use titanium metal for any given application until they are assured of a sufficient supply to fill that application completely. Therefore, a sharp increase in production necessitates a temporary stockpiling of the sponge. As additional applications are made, the stockpiled sponge will be melted and converted."

(More News Digest on page 12)



Cell room *in Electro Metallurgical Company's new electrolytic manganese plant at Marietta, Ohio. Output of the plant will be about 6000 tons a year when the electrolytic units are in full operation.*

An electronically controlled *plating line for automobile bumpers, one of the largest plating systems in the world, is now in operation at General Motors' Chevrolet Division plant in Livonia, Michigan. The line, carrying a continuous load of 335 tons of stock, can turn out chrome plate by the acre—GM engineers estimate that two acres of surface are plated per shift.*

The plating installation consists of three straight line machines each independently controlled from a central electronic console. A graphic control panel enables the operators to keep a constant remote check on 25,000 control points. Bumpers go through 20 cleaning and plating sequences in the copper nickel sections, are buffed and sent through 16 sequences in the chromium section.

The huge new Livonia plant, with 814,000 sq ft of floor space, turns out leaf and coil springs in addition to forming and plating a new bumper every three seconds.

Electrolytic Manganese Production Underway

To produce 6000 tons annually

Production of electrolytic manganese has been started by Electro Metallurgical Co. a Division of Union Carbide and Carbon Corp., at its new plant at Marietta, Ohio. The plant will have a capacity of about 6000 tons a year when all the electrolytic units are in full operation.

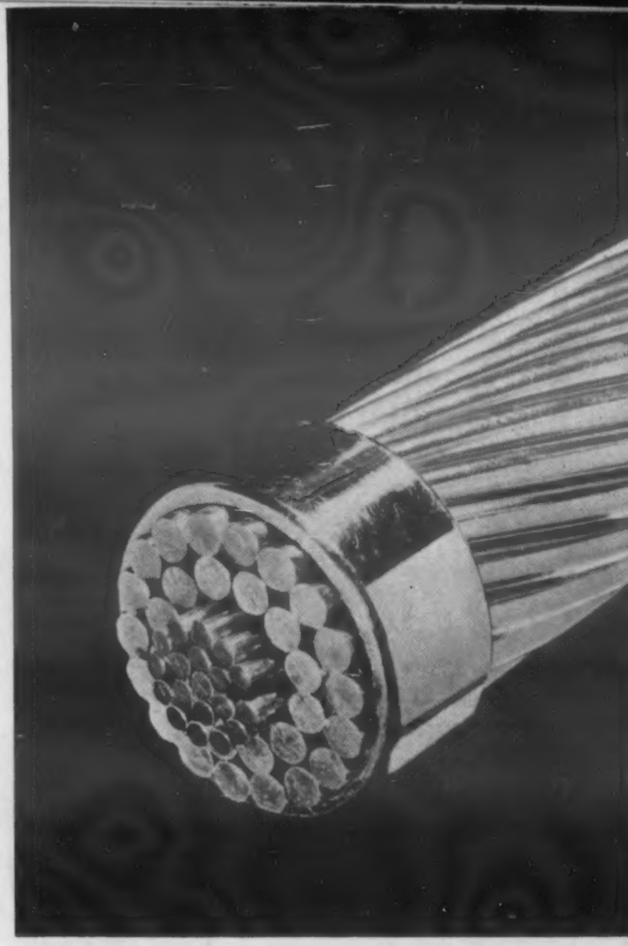
The electrolytic process used by Electromet produces minimum 99.9% pure manganese metal in plate form about 1/8 in. thick. The metal is suitable for all uses where high-purity manganese is required, such as stainless steels, high-temperature alloys, and the nonferrous metals containing manganese. Electrolytic manganese is also useful in the production of electrical resistance alloys and high-temperature alloys.

The new facilities are located on the 750-acre Ohio River site of Electromet's recently built plants for the production of ferro-alloys, electrolytic chromium and the Company's special Simplex low-carbon ferrochrome.

The basic electro-chemistry of manganese deposition has been known for many years, but the U. S. Bureau of Mines and the research laboratories of Electro Metallurgical Co. carried out the research and development necessary to perfect an improved commercial process for the large-scale production of manganese by electrolysis.

A nitrided electrolytic manganese, containing about 6% nitrogen, is being produced by Electromet. This material provides a method for adding nitrogen to steels containing appreciable quantities of manganese.

Weaving *a new aluminized steel wire chain link fence fabric.*



Cross section *of ACSR core wire.*

Wide Market for Al Coated Wire?

A wide market for hot dip aluminum coated iron and steel wires is developing, according to information recently released by the Page Steel and Wire division of the American Chain and Cable Co.

According to the company aluminized wire shows extremely good resistance to weathering in industrial and rural atmospheres and will give galvanized wire a run for its money in the replacement market. Large scale production scheduled for this year is expected to bring down costs and make the aluminized wire competitive in price with galvanized grades.

Original equipment applications are very promising for the specialized requirements of the utilities and communications field. While not intended as a prime electrical conductor, aluminized wire is more conductive than galvanized types and has added life under conditions of high humidity. A particular advantage lies in the elimination of galvanic corrosion which may occur if a third metal is present when aluminum electrical conductor wires are stranded over steel supporting cables for electrical power-transmission lines.

The company disclosed that the aircraft industry is testing the hot dipped wire for use as high strength cable and for lock and safety wire. Barbed wire, insect screen wire, electrical fencing, cable grip wire, and rope and spring wire are also promising uses, claims the company.

Hot dipped aluminum coated wire exhibits superior performance in resisting high temperatures under corrosive conditions, and has shown promise for use in belt conveyors subject to harsh environments. American Chain and Cable produces the wire under the patented Lundin process.

SPI Sees Good Plastics Sale

After a year of mild adjustment, the plastics industry is looking forward to an increase in resin production amounting to more than 5% in 1955. The mild volume decrease in raw material production in 1954 was only the second to be felt in the last 12 years, and was only about 3% below the record production of 1953. A very definite last quarter spurt in output left the industry with a generally optimistic outlook for 1955, which is expected to be another record year.

Last year's resin production in the U. S. was approximately 1,357,000 tons, compared with 1,388,313 tons the year before. The Society of the Plastics Industry predicted in a new year statement that 1955 production would amount to approximately 1,424,500 tons.

SPI statistics covering some 136 representative molders, extruders and mold makers reveal

News Digest

SPI Sees Good Plastics Sales . . . *continued from page 13*

that gross sales billings for thermoplastic and thermosetting materials were off 8.4% for the first ten months of 1954 compared with the previous year.

Thermosetting molders suffered a greater decline during the first ten months than those using thermoplastics. Thermosets were down 17.8% and thermoplastics down 4½%. Gross sales billings of molds and dies were approximately unchanged from the previous year. Extrusion of thermoplastics showed a slight gain in sales volume.

Phenolic molding compounds suffered the greatest decline, being off approximately 23%, according to production statistics for the first ten months. This would be in line with the 17.8% decline in thermosetting molded products as shown in the SPI sales statistics.

Thermoplastic molding compounds based on the Tariff Commission figures were off as follows: cellulosics 4.3%; polystyrene, 4.7% and vinyls 4.8%. On the other hand, miscellaneous molding materials, which includes the fast growing polyethylene, were up 35%, which probably accounts for the fact that molders of thermoplastic materials reported sales volume off only 4½% as against the 17.8% decline for molders of thermosetting compounds.

All vinyl resins, which include resins used for the production of film, sheeting, molding powder, flooring, protective coatings, etc. were off approximately 3.4% for the first ten months of the year.

Polystyrene molding material maintained its poundage leadership last year with production for the first ten months being reported at approximately 266,721,000 lb.

Next in line were the phenolic molding compounds totalling some 148,334,000 lb; vinyls were a close third, some 118,375,000 lb having been produced during the period.

Polyethylene, probably the fastest growing plastic molding compound is not yet shown separately in Tariff Commission figures. It is contained in the "all other" statistics, including acrylics, epoxies, nylon, which enjoyed a gain of approximately 35% in 1954 as compared with the first ten months of 1953. The total of all molding compounds shown in this category stood at 157,600,000 lb.

A spot check of the SPI sales statistics figures for November shows that the recovery move starting in September has been further extended, with thermoplastic consumption moving up better than 15% for Nov. 1954 as compared with the same month in 1953.

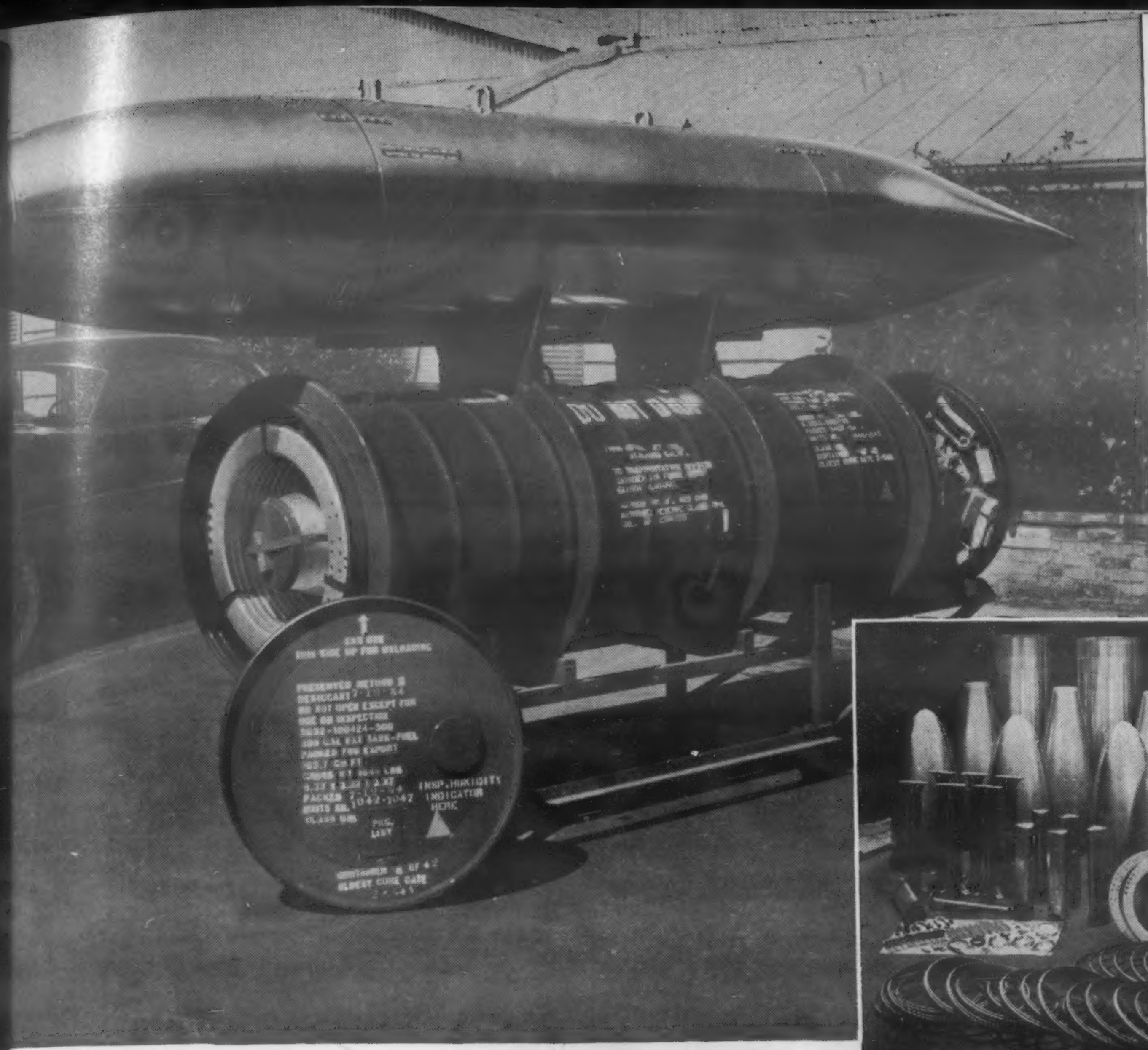
Thermosetting sales also moved up to within 2½% of Nov. 1953, which was considerably better than the 17.8% decline recorded for the preceding months of the year.

The SPI sales statistics, showing the dollar billed sales of these 136 reporting member molders, extruders and mold makers, for the first ten months of 1954, compared with the like months of 1953, follow:

	1953	1954
Thermosetting	$ 84,596,653	$ 69,111,598
Thermoplastic	109,428,731	104,962,382
Extrusion	18,450,590	19,675,717
Molds	12,835,785	12,688,600

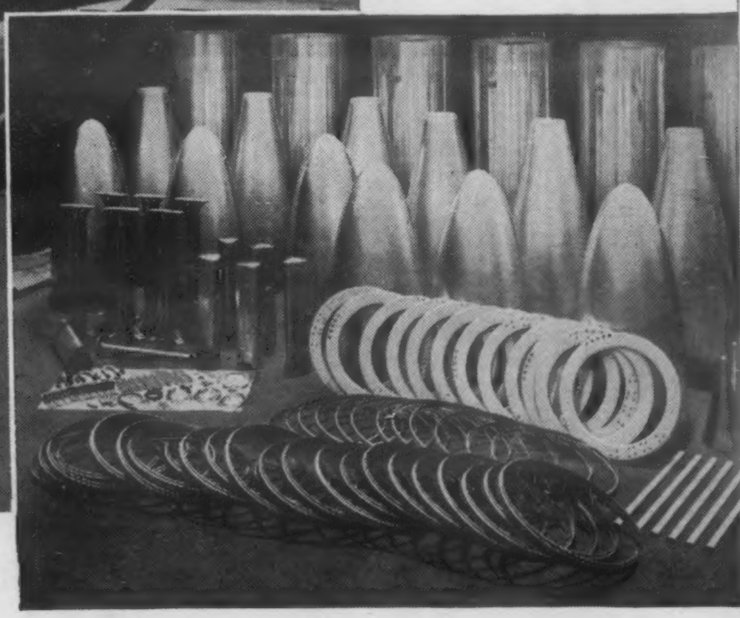
The Plastics Industry, which has for years been conscious of manufacturing standards and specifications, has actively promoted each standard's program during the last year. As a result, the quality of products made from Vinyl film, sheeting and coated fabrics has been improved; the industry is quality conscious as far as plastics toys are concerned; the U. S. Government Standards for Melamine dinnerware, Polystyrene wall tile and flexible Polyethylene pipe are resulting in increased

(Continued on page 202)



This picture shows a COR-TEN Steel container and an assembled wing tank mounted on it for display purposes.

(Below) All these components for six 450-gallon wing tanks are ingeniously nested and carried in a single Royal Jet Tank Can made of USS COR-TEN Steel. Tanks can be easily and quickly assembled in the field.



How containers for jettisonable fuel tanks—made of USS COR-TEN Steel—save 40% in shipping and storage space—reduce weight 25%—cost 10% less than crates

Shipped six-at-a-time in these COR-TEN Steel "cans," 450-gallon wing tanks for jet aircraft now travel more safely and more cheaply to their distant destinations. Not only are they better protected than ever before against shipping and landing hazards but they are indefinitely preserved in storage.

Royal Jet, Inc. of Alhambra, Calif., developer, designer and manufacturer of these efficient containers, has found COR-TEN Steel the most satisfactory material from the standpoint of lightweight, permanence, ease of manufacture and reasonable cost.

For with USS COR-TEN Steel which is 50% stronger than carbon steel and offers 4 to 6 times greater resistance to atmospheric corrosion they can use light 12 ga. and 18 ga. sheets to build containers of great strength and ruggedness that weigh 25% less than wooden crates.

These steel containers offer other advantages, too. Hermetically sealed and filled with dry air they contain sufficient dessicant to insure minimum moisture content. Since no organic materials are used in the padding, fungus growth and interior corrosion are eliminated. As a result the sealed-in tanks stay factory-new regardless of temperature, climate or length of storage. Containers can be stored in the open for an indefinite period with a minimum of damage or deterioration.

This new packaging technique pays off. By replacing wooden crates, formerly used, with these COR-TEN Steel containers, weight per wing tank shipped has been materially reduced, 40% less storage and shipping space is required and the shipping cost to Europe, for example, has been reduced $21.36 per tank —a saving to the Government, on only 100,000 tanks, of more than $2,000,000.

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USS COR-TEN HIGH Strength STEEL

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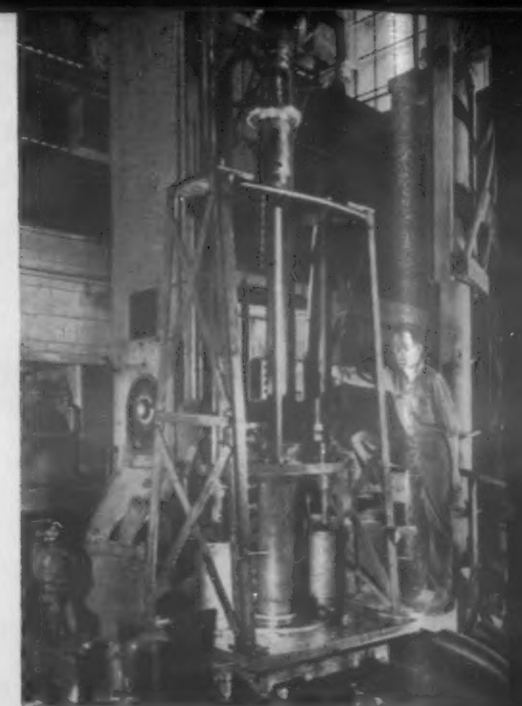
UNITED STATES STEEL

1. **Welding The Main**—Fittings and base plate are welded into the base of an oil hydraulic cylinder. The steel tubing must make a sound weld without warping.

2. **Machining The Main**—High speed threader (235 rpm) cuts close tolerance threads on the inside diameter for bronze packing nut and steel stop ring. Snug fit is essential to add strength to cylinder and prevent leakage under pressure.

3. **Turning The Sleeve**—The outside diameter of the sleeve is turned, and then ground to even finer finish. Straightness and concentricity in the tubing is most important. Proper stress-relief annealing of the steel prevents warping.



4. **Honing The Sleeve**—On this vertical honing machine, the inside of the sleeve (center) is finished to a 16 micro-inch finish for piston-ring fit to contain the hydraulic pressure when cylinder is operating.

How Stron

Ge

In order to increase production and reduce costs, all industry today is demanding greater performance from its tools. Equipment must carry heavier loads, lift them higher and faster—stay in service longer than ever before.

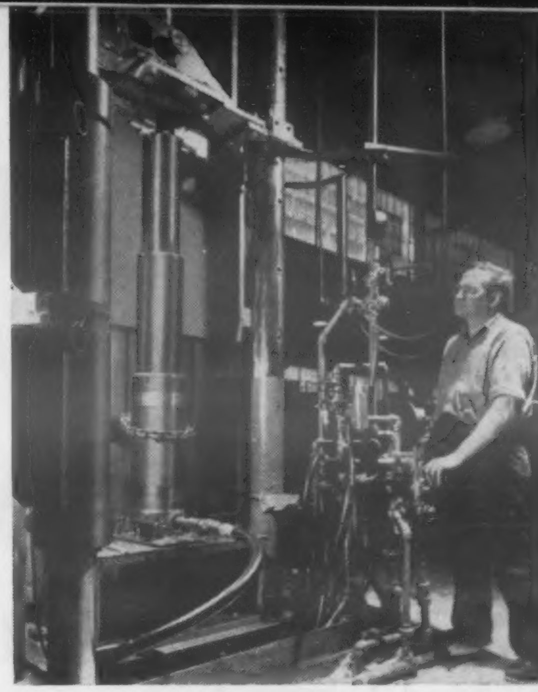
To accomplish this, strong, powerful arms of steel in the form of oil hydraulic cylinders are being used increasingly on industrial equipment, machinery, tractors, earth movers, loaders, lift trucks, portable drilling rigs. They transmit power smoothly, economically.

Among the producers of oil hydraulic cylinders, one of the largest and best known is the Commercial Shearing and Stamping Company of Youngstown, Ohio. It has developed precision methods of making heavy duty hydraulic cylinders that operate easily, yet contain the hydraulic pressures without leakage. To make them, Commercial starts with the best in cold drawn seamless mechanical tubing from experienced steelmakers such as Pittsburgh Steel Company.

• **One Example**—Take a look at the way Commercial produces just one of its many models: the two-sleeve telescopic cylinder used to erect the boom of a portable rotary drilling rig.

Each rig is equipped with two of

Grinding The Plunger—Here is a gid test for any tubing. The plunger ust be turned, ground, and polished to mirror-like 16 mif with crocus cloth. he slightest imperfection would cause akage under operating pressure.



6. 100-Per-Cent Inspection—Every cylinder made at Commercial is tested on equipment that develops the full pressure loads that are required under field operating conditions, and is thoroughly inspected during operation.

7. Raising A Rig—The double acting cylinders on this portable Franks rotary drilling rig develop an initial thrust of 35 tons in positioning the boom, and nearly 20 tons of pull when bringing it down. This is one example of the many models of oil hydraulic cylinders produced by Commercial.

rms of Industry heir Muscles

these cylinders. They have a stroke of nearly 10 feet, providing an initial thrust of 35 tons. This lifts the boom from a horizontal folded position to a vertical extended position. To reverse the operation, the cylinder's double acting feature develops a thrust of nearly 20 tons on the pull stroke.

The tubular parts of each cylinder consist of a main, a sleeve, and a plunger. As the cylinder operates under oil hydraulic pressure up to 1,000 psi, the main provides the base for actuating the sleeve and plunger.

In production, these tubular parts are turned, ground and honed. Fittings are welded into position. Ends are threaded to hold packing nuts and stop rings. From start to finish, all operations require detailed scientific accuracy (see photos).

• What It Takes—You can readily see why the steel tubes for each cylinder must have special properties for this specific application.

Each tube must have uniform close dimensional accuracy, straightness, and concentricity, so that the amount of steel removed in turning, grinding and honing can be kept to a minimum. Extra time on these operations is expensive.

The steel must have machinability. It can't be too soft or too hard. It must be clean in its chemical composition and clean on the surface. At the same time it has to weld easily. And it must take both machining and welding without warping. Finally, it must have extra strength for the variety of stresses that the load of raising, holding, and lowering the rotary drilling rig boom will place on it in field operations.

The mechanical seamless tubing supplied by Pittsburgh Steel for this cylinder ranges in size from 7.210 inches inside diameter with a wall thickness of .395 inches for the main, down to 3.250 inside diameter with a wall thickness of .313 inches for the plunger. It is a low carbon steel of inherent quality, cold drawn to exact uniform size for easy machining and honing. It is stress-relief annealed to prevent warpage during manufacture. And it provides a tensile strength of over 60,000 psi.

• What This Means To You—Commercial uses Pittsburgh Steel's seamless mechanical tubing for this and many other types of cylinders because it can rely on excellent performance in production and high quality in the finished product.

If you have an application for seamless tubing, why not look into the opportunities Pittsburgh Steel can offer you? A phone call to the closest district office (see below) will bring prompt personal attention. Why not call today?

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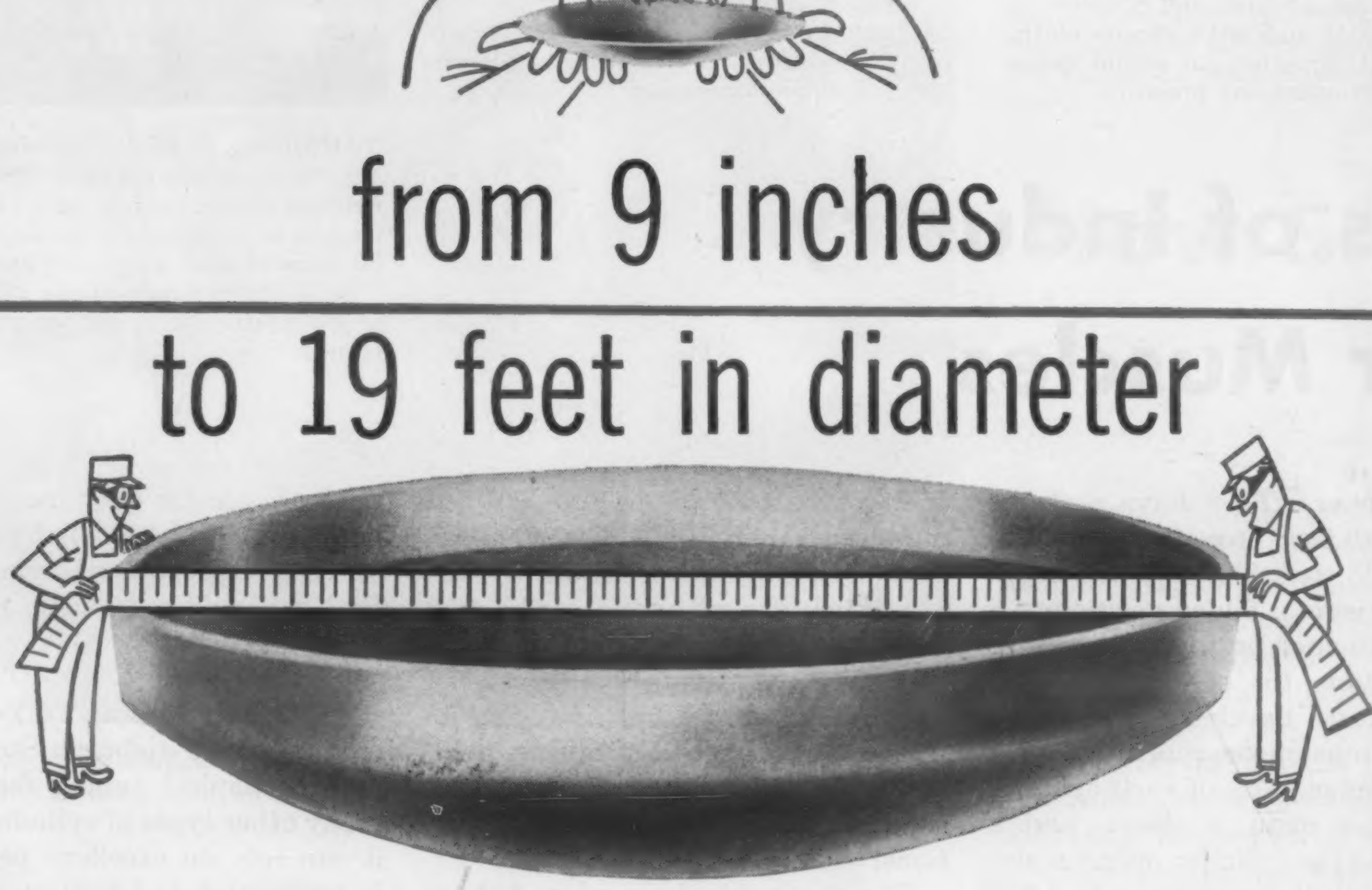

Flanged and dished heads made by Claymont are available in sizes from as small as 9 inches to as large as 19 feet in overall diameter; and in gauges from 3/16-inch to 6 inches. They can be supplied in carbon steel, alloy steel or with stainless steel cladding.

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PLASTIATRICS HELPS YOU CHOOSE AND USE PLASTICS CORRECTLY

Are you getting the most out of the plastics you need? Do you have the best or the latest or the most for your money? Are you satisfied that plastics are right for the job? That's where Plastiatrics comes in . . . to provide a continuous study, analysis and treatment of plastics application . . . to understand, prevent, or cure plastics problems.

What is Plastiatrics

Plastiatrics sounds like a medical term. It's no accident. Since Dow's first plastics were made, we have subjected them to: *diagnosis,* to determine their limitations and complaints—*prognosis,* to determine the course and termination of manufacturing problems—and *treatment,* prescribing a course of action or physical remedies for their ailments. Professional analysis and experience is making it possible to *cure* many plastics problems and prevent possible afflictions. The general practice of scientific inquiry and treatment of plastics and their healthy uses is a profession at Dow. Plastiatrics, we call it.

The Plastiatrics Laboratory

Good research requires modern equipment, but the tools are only as good as the men who use them. Dow Plastics Technical Service is staffed by engineers and technicians who have devoted their careers and their skills to the study of plastics materials, processes, testing methods and their evaluation. The knowledge and experience these men have gained are tremendous in scope. They work with standard commercial fabricating equipment, not laboratory models, to integrate materials and processes with careful attention to practical economics. Experiment and development can be carried out on commercial scale from raw material formulation through specialized processes and finishing. Field service in fabricating plants and participation in trade standards committees further extend the work of the laboratory. The reliable reports and engineering data of Plastics Technical Service are the foundation of Plastiatrics.

Plastiatrics Helps Industry

Dow seeks to promote the use of plastics wherever that use is sound, and discourage it where other material can be used more advantageously. With Dow, the interest of the manufacturer or molder is paramount. Problems and their solutions or supporting data are stated in standard engineering terms so that technically trained people in other fields can use them. Dow will furnish confidential evaluation of finished or proposed plastic parts or their blueprints. Service work may include consultation on special developmental techniques. Considerable experience is available to the manufacturer with regard to appropriate dies, jigs and fixtures and molded parts. Materials are modified or developed according to the requirements of industrial application. Like preventive medicine, Plastiatrics can ward off trouble before it starts.

Plastiatrics Series to Follow

Results of clinical reports will appear in these pages from time to time. For a complete summary of Dow products and services, write for "Dow Plastics Materials and Technical Services", The Dow Chemical Company, Plastics Sales Department PL 453X, Midland, Michigan.

DOW POLYSTYRENE FORMULATIONS:

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- **Styron 688** . . . for controlled flow and controlled pressure distribution in the mold cavity.
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Manufacturers' Literature

graphing spot welds and light materials to penetrating over 1 in. of steel. (18)

Beryllium Copper Alloys. Beryllium Corp., 48 pp, ill. Company's stock of available parts from four of these alloys. Covers engineering data and processing techniques. (19)

Industrial and Automotive Forgings. Cleveland Hardware & Forging Co., 38 pp, ill, No. 19A. Catalog of company's industrial and automotive forgings. (21)

Hardsurfacing Alloys. Coast Metals, Inc., 4 pp, ill. Engineering data on company's No. 18 and 118 hardsurfacing alloys for wear resistant coatings. (22)

Metal Finishing. Despatch Oven Co., 16 pp, ill, No. 51. Describes line of equipment for metal finishing, including heat processing ovens, ventilators, spray booths, dryers, etc. (24)

Steel Extrusions. Detrex Corp., 8 pp, ill. Cold steel extrusion process chemically interlocks tough, dry heat resistant lubricant to work surface. Lubricating film stretches with metal as it is formed, eliminating metal-to-metal friction. (25)

Etching Aluminum Alloys. Diversey Corp., 8 pp, ill, No. 51 A. Alkaline etching compound for aluminum alloys decreases etch tank maintenance and prolongs solution life. Eliminates scale formations on tanks and coils. (26)

Magnesium Extrusions. Dow Chemical Co., 35 pp. Section properties of magnesium extrusions, including rectangular bars, round tubing, equal angles, unequal angles, channels, etc. (27)

Controlled Atmosphere Furnace. Dow Furnace Co., 5 pp, ill. Furnace for gas carburizing, carbonitriding, clean hardening and carbon restoration. Company's Model M-400 will heat 400 lb from room temperature to 1500 F. (28)

Metal Protection. Eltex Chemical Corp., 4 pp. Black oxide finish for protection and decoration of irons and steels which increases wear resistance and toughness of metals. (30)

Aluminum Anodizing. Engineering Products & Specialties, Inc., 4 pp, ill. Describes process which forms thin, hard, corrosion-resistant oxide film on any aluminum or aluminum alloy product. (31)

Short Run Stampings. Federal Tool & Mfg. Co., 4 pp, ill, No. 201. Short run, close tolerance stamping with low cost dies. (32)

Electroforming. Gar Precision Parts, Inc., 4 pp, ill. Process permits exact reproduction of intricate details on sheet or complex forms using permanent or expendable mandrels. (33)

End Heating Furnace. Gas Appliance Service, Inc., 4 pp, ill, No. 350 A. Describes "Roto-Flame" furnace for heating ends of bar stock, tubing and other special shapes. (34)

Welding. Graver Tank & Mfg. Co., Inc., 16 pp, ill. Describes plant's facilities for large weldments and suggests applications. (35)

Rockwell Hardness Test. Gries Industries, Inc., 4 pp, ill, No. A-12. Describes Rockwell Hardness test with automatic zero setting and other time-saving features that enable tester to perform 400 high-precision tests per hr. (36)

Lock, Weld and Clinch Nuts. Grip Nut Co., 12 pp, ill. Specifications and applications for Gripco fasteners. (37)

Bright Nickel Plating. Harshaw Chemical Co., 4 pp, ill. Describes two nickel plating processes particularly adaptable for applications where little metal finishing is done prior to plating. (38)

Corrosion Resistant Materials. Haveg Corp., No. C-11. Series of bulletins on corrosion resistant materials for tanks, pipes, fittings, etc. (39)

Plastic Coatings. R. M. Hollingshead Corp., 16 pp, ill. Manual on "cocoon" sprayable vinyl plastic coating with instructions on spraying methods. (40)

Heat Treating Nickel Alloys. International Nickel Co., Inc., 16 pp, ill, No. A-115. How to increase usefulness of cast irons and improve properties by alloying and heat treating. Includes treatment of nickel cast iron, plain cast iron, nickel-chromium cast iron, nickel-chromium-molybdenum cast iron. (41)

Cleaning Automotive and Aircraft Parts. Kelite Products, Inc., 2 pp, ill, No. 17-R. Degreasing and decarburizing agent, Formula 555, for aircraft and automotive parts. (42)

Refractory Fiber Felt. Johns-Manville, 6 pp, ill. Thermoflex, a heat-resistant felt, recommended for service to 2000 F as filter medium for hot gases, liquids and as sound control material where problem of noise deadening is complicated by intense heat conditions. Properties, sizes, thicknesses given. (44)

Bright Copper Plating. Lea Mfg. Co., 22 pp. Technical manual on plating operations for bright copper coatings. Bath compositions and operating conditions given. (45)

Solvent Vapor Degreaser. Manufacturers Processing Co., 4 pp, ill. Describes degreaser using trichlorethylene as solvent. (29)

Steel Wire for Submerged Arc Welding. Metal & Thermit Corp., 4 pp, ill. Properties and composition of carbon and low alloy steel wire for welding process. (46)

Blast Cleaning and Dust Control. Pangborn Corp., 16 pp, ill, No. 226. Describes various models of "Continuous-Flo Rotoblast" barrels available for production line blast cleaning to reduce cleaning costs. (47)

Resins for Shell Molding. Plastics Engineering Co., 18 pp, ill. Thoughtful analysis of shell molding process with description of resins developed for manufacturing shell molds. (48)

Iron Powder Parts. Pow Met Industries, Inc., 4 pp, ill. High density, heavy duty iron powder parts. (49)

Metal Stampings. Dayton Rogers Mfg. Co., 8 pp, ill. Describes company's small lot stamping service with low die costs. (50)

Structural Adhesives. Rubber & Asbestos Corp., 14 pp. Evaluation of 18 Bond-Master Series "M" adhesives or group of adhesives with selection guide. (51)

Centrifugal Castings. Sandusky Foundry & Machine Co., 6 pp, ill. Specification chart for ferrous and nonferrous alloys for centrifugal castings. (52)

Precision Investment Casting. Alexander Saunders & Co., 14 pp, ill. Discussion of advantages of this process in comparison with conventional methods of production, techniques, equipment and supplies needed. (53)

Liquid Polymer Epoxy Casting Compounds. Thiokol Chemical Corp., 12 pp. Casting compounds of high resilience and impact resistance with good strength and electrical properties; especially suitable for electrical and electronic potting and plastic tooling. (54)

Preformed Metal. Rigidized Metals Corp., Pattern selector guide for preformed metals. (55)

Hard-Facing Alloys. Wall Colmonoy Corp., No. 1A. Contains red hardness curves of Colmonoy alloys No. 6, 5 and 4 which trace approximate hardness of these nickel-base chromium-nickel-boron alloys at temperatures up to 1500 F. (56)

Other Available Literature

Irons and Steels • Parts • Forms

Metal Stitching. Acme Steel Co., 12 pp, ill. Technique for metal-to-metal and nonmetallic-to-metal fastening, using wire stitching. Specifications and case histories. (60)

Welded Parts. Acme Tank & Welding Div., 4 pp, ill. Shows this plant's facilities for welding complex shapes and discusses advantages of using welded construction by competent welders. (233)

Stainless Steel. Allegheny Ludlum Steel Corp., 34 pp, ill. Use of stainless steel in pulp and paper industry. Includes a special stainless finder chart which indicates the types of stainless available and their uses in the paper industry. (57)

Flexible Tubing. American Hard Rubber Co., 4 pp, ill, No. 66-D. Physical properties, chemical resistance, standard sizes and characteristics of transparent plastic tubing. (58)

Metal Powder Parts. American Sinterings Div. of Engineered Plastics, Inc., 4 pp, ill. Facilities for fabrication of ferrous or nonferrous metal powder parts. (61)

Steel Weight Calculator. Armco Steel Corp. Slide rule type calculator for determining weight of special and commodity steel sheets, including coated and uncoated grades, stainless steel and common nonferrous metals. Write direct to Marketing Service, Armco Steel Corp.,

Manufacturers' Literature

Middletown, Ohio. Price $.50.

Duplex Tubing. Bridgeport Brass Co., 14 pp, ill, No. 1954. Explains the use of Duplex tubes for heat exchangers and condensers in which internal and external corrosion conditions differ. (62)

Iron and Steel Castings. Campbell, Wyant & Cannon Foundry Co., 24 pp, ill. Describes types of gray iron and steel castings. (63)

Custom and Standard High Alloys. Cannon-Muskegon Corp., 4 pp, ill. Ferrous and nonferrous alloys for castings, extrusions and forgings. For remelt or direct use. (64)

Steel Sheets and Wire. Continental Steel Corp., 20 pp, ill. Specifications and description of wide range of steel sheets and wire. Includes handy tabular aids to specifications. (65)

Stampings and Forgings. Commercial Shearing & Stamping Co., 28 pp, ill, No. G1. Design applications and advantages of stampings, forgings, hydraulic equipment and assembled products. (66)

Stainless Steels. The Cooper Alloy Corp., 4 pp, ill. 1954 alloy reference chart lists chemical analyses, physical properties; recommends applications for 28 grades of cast stainless steels. Indicates ACI, AISI, SAE, ASTM and general type designations. (59)

Specialty Steels. Crucible Steel Co. of America, 32 pp, ill, No. TM9. Information on cold rolled specialties, including stainless, alloy and carbon spring steels. (67)

Steel Fabrication. Delaware Steel Fabricating Corp., 4 pp, ill. Company facilities for steel fabrication and list of representative products. (68)

Centrifugal Cast Pipe. The Duraloy Co., No. 3150. Shows this company's facilities for producing centrifugal cast pipe and tubing. (69)

Sponge Iron Powder. Hoeganaes Sponge Iron Corp., 12 pp, ill. Properties of Swedish sponge iron powder. (71)

Electrolytic Iron Powder. A. Johnson & Co., Inc., 30 pp, ill. Detailed account of a high purity powder with higher sintering activity, better compressibility, and a higher flow rate. Made in Sweden. (72)

Steel Alloys. Jones & Laughlin Steel Corp., ill. Outlines properties, composition. Includes applications, case histories and heat treatment of steel alloys. (73)

Threaded Stampings. Mohawk Mfg. Co., 2 pp, No. 851. Illustrates variety of products produced by Mohawk's stamping processes, guaranteeing uniform threaded parts with uniformly threaded holes. (75)

Steel Castings. Ohio Steel Foundry Co., 14 pp, ill. Illustrates the many types of castings, including carbon-steel and alloy castings, heat resistant alloy castings and stainless steel castings. (77)

Forgings. Pittsburgh Forgings Co., 8 pp, ill, No. 5201. Describes and illustrates the facilities of this company for producing drop, press and upset forgings. (78)

Powder Metal Parts. Powdered Metal Products Corp. of America. Booklet shows advantages of powder metallurgy in manufacture of such parts as gears, sprockets and valves. (79)

Steel Tubing. Rochester Products Div., General Motors, 12 pp, ill, No. 271. Features typical applications of GM tubing made in single and double walls of steel. (81)

Steel Castings. Steel Founders' Society of America, 4 pp, ill, Product Design Studies No. 54. Another in a series of design studies showing cost reduction and product improvement through the use of steel castings. (84)

Sheet Metal Fabrication. Stolper Steel Products Corp., 4 pp, ill, No. 2. Features case histories of sheet metal design and fabrication offered by this company. (85)

Clad Metals. Superior Steel Corp., 24 pp, ill. An introduction to clad metals offering a comprehensive survey of the manufacture and application of stainless, copper, brass and other clad steels. (86)

Cold Rolled Steel. Thomas Strip Div., Pittsburgh Steel Co., 50 pp. Complete table on pound for lineal foot in weight for cold rolled strip steel in widths of ¼ to 24 in., thicknesses from 0.001 to 0.2757. (87)

Precision Casting. Thompson Products, Inc., Metallurgical Products Div., 8 pp, ill, No. MP-53-1. Discusses the Intricast process of precision casting any castable metal or alloy. (83)

Spun Metal Parts. Roland Teiner Co., Inc., ill, No. 51D. Brochure describes this company's facilities for spinning practically any metal or gage required. (88)

Small Precision Metal Parts. Torrington Co., 4 pp, ill. Illustrates the various small precision metal parts custom-made by the Specialties Div. of Torrington. (89)

Cylinder-Finish Tubing. Tube Reducing Corp., 4 pp, ill, No. R-7. Illustrates close tolerances and good surface finish obtained in compression formed tubing. (90)

Metal Shapes. Van Huffel Tube Corp., 24 pp, ill. Tables for metal shapes, lockseam tubing, butted tubing, welded tubing, angles and channels. (91)

Steel Strip. Weirton Steel Co., 20 pp, ill. Characteristics of electrolytic zinc-coated sheets and strip, high-tensile steel and high carbon strip cold-rolled spring steel being manufactured by the company. (92)

Nonferrous Metals • Parts • Forms

Die Castings. The Accurate Die Casting Co., 24 pp, ill. Shows company's facilities for producing to order all types of zinc and aluminum die castings. Includes table of alloy properties. (93)

Aluminum Castings. Acme Aluminum Alloys Inc., 16 pp, ill. Pictures the many facilities of this company for producing a variety of castings, tools and related products. Technical data included. (94)

To obtain literature appearing on these pages, please refer to easy-to-use reply card on pages 67 and 68

Aluminum Castings. Aluminum Industries Inc., 4 pp, ill, No. 20A. Describes this company's facilities offered to industrial plants that need aluminum castings for defense jobs. (95)

Aluminum Parts. Aluminum Goods Mfg. Co., 56 pp, ill. Catalog covers extensive production facilities and technical services for producing wide range of parts. (96)

Precision Investment Castings. Arwood Precision Casting Corp., 16 pp, ill. Informative article on precision investment castings. Includes table of ferrous and nonferrous alloys recommended as most adaptable for this process. (98)

Nonferrous Plaster Mold Castings. Atlantic Casting & Engineering Corp., No. 4. Describes production of copper-base and aluminum alloy "Atlanticastings." (99)

Beryllium. Brush Beryllium Corp., 4 pp, ill. Uses of beryllium and its alloys and compounds. (101)

Bronze Bar Stock and Bearings. Bunting Brass & Bronze Co., 72 pp, ill, No. 52. A complete presentation of this company's standard stock bearings, graphited oilless bearings, precision bronze bars and electric motor bearings. (102)

Brass Wire Cloth. Chase Brass & Copper Co. Lists mesh, diameter of wire, per-cent open area, weight and other data on complete line of company's brass and copper wire cloth. (103)

Die Cast Parts. Dollin Corp. Bulletin describes advantages of using this company's facilities for production of small zinc or aluminum precision cast parts. (104)

Forgings. Drop Forging Assn., 60 pp, ill. Data book shows mechanical qualities of forgings, and illustrates economic, engineering and production advantages. (105)

Rolled Aluminum. Fairmont Aluminum Co., 52 pp, ill. Aluminum rolling mill products, with charts of physical properties, tolerances, comparative weights and a number of conversion charts. (107)

Printed Circuits. Formica Co., 12 pp, ill, No. 457. Describes copper clad printed circuits with instructions for construction and applications. (108)

Copper-Clad Aluminum. General Plate Div., Metals & Controls Corp., 6 pp, No. 702C. Technical data on Acuplate, a composite metal consisting of a layer of aluminun on which a thin layer of copper is clad on either or both sides. (109)

Contact Rivets. Gibson Electric Co., 6 pp, ill, No. C-521. Description and specifications of a complete line of Gibson electrical contact rivets. (110)

Copper and Brass Tubing. H & H Tube & Mfg. Co. Describes a complete line of seamless braze and lock seam copper and brass tubing. (111)

Double Headed Parts. John Hassall, Inc. Catalog shows numerous double headed parts, indicating applications and suggesting other applications of double heading operations. (112)

Powder Metallurgy. Keystone Carbon Co., 6 pp, folder. Describes company's powdered metal products and facilities for production. (113)

Investment Castings. Hitchiner Mfg. Co., 12 pp, ill. Description of precision in-

vestment castings and its advantages and limitations. (114)

Die Castings. The Hoover Co., 12 pp, ill, No. 853. Shows this company's facilities for producing zinc and aluminum die castings. Includes design helps, decribes applications. (115)

Laminated Metals. Improved Seamless Wire Co., Inc., 6 pp, ill. Describes the importance and applications of laminated metals to modern industry. (116)

Die Castings. Litemetal DiCast, Inc., 12 pp, ill. How to select best light metal for die casting. Shows facilities for producing light metal pressure die castings. (117)

Alloy Metals. Littleford Bros., Inc., 4 pp, ill. Facilities for fabricating large assemblies and small parts from various metal alloys. (118)

Titanium Alloys. Mallory-Sharon Titanium Corp., 4 pp, ill. Gives physical properties, forging recommendations, etc, for a high tensile strength titanium alloy developed primarily for bar and forging applications. (119)

Tungsten Carbide Parts. Metal Carbides Corp., 68 pp, ill, No. 52-G. Description, specifications and prices of standard Talide Metal dies, rolls, bushings, forms and special shapes. (120)

Zinc and Aluminum Die Castings. National Die Casting Co., 8 pp, ill, No. 266. Charts on composition of zinc and aluminum alloys for die casting. Description of plant's die making facilities, die casting machines and machining facilities. (122)

Brass Metal Powder Parts. New Jersey Zinc Co., 4 pp, ill, No. 9. Powder-metal application case histories for lock cylinders, radio transmitter parts and instrument clamps. (121)

Spun Shapes. Phoenix Products Co., Metal Spinning Div., 4 pp, ill. Describes Phoenixspun methods for spinning spherical and extra deep-drawn contours. (123)

Bushings. Randall Graphite Bearings, Inc., 12 pp, ill, No. 100. Complete price list of bronze bushings and specially grooved bushings; specifications of bored and solid bronze bars. (124)

Machining of Titanium. Rem-Cru Titanium, Inc., 8 pp, ill, Vol. 1, No. 1. Discusses titanium machining practices and procedures recommended by customers having titanium application experience. (125)

Aluminum Extrusions. Revere Copper & Brass Inc., 28 pp, ill. Features a simplified easy-to-follow section on standard tolerances of aluminum extruded shapes, presented in table form. (97)

Wire Cloth. Reynolds Wire Co., 8 pp, ill, No. 1a/30a. Available materials, styles and sizes of industrial wire cloth, furnished in ferrous and nonferrous materials. (126)

Heat Treating Aluminum Alloys. Reynolds Metals Co., Louisville, Ky., 122 pp, ill. Explains on two different levels the principles and procedures for heat treating aluminum and its alloys. First section is written for the non-technical reader; second section is a more technical discussion for metallurgists. Available by writing direct to Reynolds Metals on company letterhead.

Aluminum Strip. Scovill Mfg. Co., 20 pp, ill. Physical characteristics, temperature designations, weights and fabricating data for aluminum alloy strip. (127)

Aluminum and Magnesium Sand Castings. South Gate Aluminum & Magnesium Co., 12 pp, ill. Features the facilities of this company for producing precision aluminum and magnesium sand castings and precision machined parts. (128)

Alloy Products. Specialloy, Inc., 8 pp, ill. Electric furnace alloys listed with nominal composition, uses, properties, forms. (100)

Light Metal Castings. Thompson Products Inc., 8 pp, ill. Describes a complete line of precision die castings for various industrial uses. (129)

Investment Casting. Vascoloy - Ramet Corp., 12 pp, No. VR-471. Explains investment casting processes. Defines limitations and advantages of the process. (130)

Bearings, Bushings. Wakefield Bearing Corp., 8 pp. Booklet illustrates Graphex, Coprex and Woodex oilless and self lubricating bearings, bushings and machine parts. Also 12-page booklet listing standard sizes of bearings. (131)

Pipe and Tubing. The Wallingford Steel Co., 8 pp, ill. Stainless, carbon and alloy steel tubing for ornamental, mechanical, pressure, sanitary and aircraft use in size range from ¼-in. to 3-in. O.D. (106)

Spun Tubing. Wolverine Tube Div., 28 pp, ill. Advantages and numerous applications of this firm's nonferrous Spun End Tube Process. (132)

Light Metal Forgings. Wyman-Gordon Products Corp., 4 pp, ill. Announces the availability of large-size light alloy forgings particularly those of magnesium and 75-S aluminum. (133)

Nonmetallic Materials • Parts • Forms

Industrial Textiles. The Albany Felt Co. Illustrated folder describes wide range of facilities for production of fabrics for industry. (134)

Lubrication. Alpha Corp., 4 pp. Describes principle of lubrication by solids and role of molybdenum disulfide in this process. (135)

Plastic Pipe. American Agile Corp., 12 pp. Charts give physical and mechanical properties of polyethylene and polyvinyl chloride pipe and tubing and their chemical resistance to various reagents. (136)

Flexible Tubing. American Hard Rubber Co., 4 pp, ill, No. 66-D. Physical properties, chemical resistance, standard sizes and characteristics of transparent plastic tubing. (137)

Impregnant. American Metaseal Mfg. Corp., 5 pp, ill. Impregnating component for sealing porous castings. (138)

Gaskets, Packings, Etc. Auburn Mfg. Co., 3 pp, ill. Discusses the various products produced by this company, including gaskets, packings, washers spacers, seals, shims and bushings. (139)

Balsa Wood. Balsa Ecuador Lumber Corp., ill. Brochure contains a number of sheets discussing various Kilndried Balsa lumber and Balsa products. (140)

Thermoplastics. Bassons Industries Corp., 12 pp, ill. Complete data on reinforced and formed plastics. Illustrates processing facilities. (141)

Silicon Carbide. Carborundum Co., 52 pp. Extensive brochure discussing the properties of silicon carbide in relation to its use as a refractory in heating elements, in electrical resistors, as catalyst carriers and as a porous media, as well as to its abrasive applications. (142)

Plastic Pipe. Carlon Products Corp., 4 pp, ill. Contains factual informative answers to most frequently asked questions about carbon flexible plastic pipe and carbon rigid pipe. (143)

Polyester Resins. Celanese Corp. of America, Plastics Div., 22 pp, ill. Provides background information, properties, curing processes, formulations and instructions for laminating, casting, spraying and impregnating with the MR series, low pressure, liquid-thermosetting resins. (144)

Plastisol. Chemical Products Corp., 8 pp, ill. Chem-O-Sol plastisol formulation for industrial and consumer products. Instructions for use and several case histories of coated products. (145)

Engineered Paper Products. Cincinnati Industries Inc., 16 pp, ill. Complete data on the new double crepe Cindus material called X-Crepe that can be used like cloth, instead of rubber, in place of cork, and for jobs where no other material will do. (146)

Extruded Plastic. Conneaut Rubber and Plastics Co., 4 pp, ill, No. CR-53. Die making and production facilities of rubber and plastic extrusions. (147)

Coated Fabrics. Connecticut Hard Rubber Co. Uses, chemical, electrical and mechanical properties, and availability of heat resistant silicone rubber coated glass fabrics. (148)

Glass. Corning Glass Works, Dept. MM-6, 12 pp. Gives reasons why glass is increasingly important in product design. (149)

Polyester Film. E. I. du Pont de Nemours & Co., Inc., Film Dept., 8 pp, ill. Properties and proposed applications of Mylar listed in convenient chart form. (150)

Plastics. E. I. du Pont de Nemours & Co., Inc., 10 pp, ill, No. 113/3. Descriptions, advantages and uses of Lucite, Polyethylene, Nylon, Butacite, Pyralin, Plastacele and Teflon. (151)

Glass-Reinforced Plastics. The Dynakon Corp., 7 pp. Gives mechanical, electrical and fabricating properties of Dynakon's glass-reinforced plastics materials. (152)

Reinforced Plastics. Erico Products, Inc., 4 pp, ill. Glass fiber reinforced plastic with presentation of physical properties. (153)

Wood-Paper Laminate. David Feldman & Associates, 4 pp. Thin wood veneer laminated to paper for decorative, display, and other uses. (154)

Cast Wood. Forestrong Co., 4 pp, ill. Profusely illustrates and describes a wood fiber molding process. (155)

Vinyl Tubing. Gering Products, Inc., 4 pp, ill. Folder on Ger-Flex, a transparent, nontoxic, vinyl plastic flexible tubing with noncorrosive properties. (156)

Polystyrene Sheet. Gilman Bros. Co., 4 pp, ill. High impact polystyrene sheet for vacuum forming. Has five times the strength of general-purpose sheet. (157)

Manufacturers' Literature

Self-Lubricating Bushings. Graphite Metallizing Corp., 8 pp, ill, No. 108. Describes Graphalloy grades for bushings and electrical uses. Bearing design data included. (158)

Polyvinyl Chloride Resin. H. N. Hartwell & Son, Inc., 8 pp, ill. Sheet, bar stock list of nonplasticized polyvinyl chloride. (159)

Molded Plywood. Keller Products, Inc., 12 pp, ill. Booklet describes standard and constantly used die shapes for molding plywood as an aid to designers of molded plywood shapes. (188)

Titanium Carbide. Kennametal Inc., 6 pp, ill. Describes heat-resistant titanium alloy for applications at 1800 F and above. (160)

Glass. Kopp Glass Inc., 18 pp, ill. Methods by which Kopp glass products are designed and made to meet strict specifications for light transmission and distribution, physical properties, dimensional exactness and other requirements. (161)

Glass. Lancaster Lens Co., 8 pp, ill. Twenty-one case histories of a wide variety of glass part applications. (162)

Electrical Insulation. Louthan Mfg. Co., 13 pp, ill, No. 49-E. Uses and specifications of Louthan insulations in mechanical, electrical, thermal and electronic fields. (163)

Luminescent Plastics. Luminescent Plastics Corp., 7 pp, ill. Illustrates variety of products of luminescent plastic material. (164)

Plastic Molding. P. R. Mallory Plastics, Inc., 4 pp, ill. Complete production facilities for large scale production of custom-molded parts from design to finishing and assembly. (165)

Hardboards. Masonite Corp., 24 pp, ill, No. 1d/2. Properties and advantages of Preswood and other Masonite hardboards, and their relation to product design. (166)

Reinforced Wood. Met-L-Wood Corp., 15 pp, ill, No. 521. Describes combined wood and metal sheets, providing light weight and high strength. (167)

Insulating Material. Mica Insulator Co. Catalog of standard electrical insulating materials. (168)

Adhesives. Minnesota Mining & Mfg. Co., 12 pp, ill, No. 170-58. Describes uses of adhesives in aircraft manufacture. Includes a list of principal applications of adhesives in the aircraft industry. (169)

Carbon Products. Morganite Inc., 8 pp, ill, No. 1f. Specifications of various carbon bearings and bushings. Properties of six series of Morganite carbon products. (170)

Glass Bonded Mica. Mycalex Corp. of America, 24 pp, ill. Design information for parts to be machined from glass bonded mica. (171)

Nonmetallic Pipe. National Carbon Div. 16 pp, ill, No. CP-2212. Chemical resistance, properties and specifications of pipe and fittings of Karbate, phenolic impregnated carbon and graphite. (172)

Plastic Resins and Compounds. Naugatuck Chemical Div., 8 pp, ill. Vinyl, polyester and elastomeric resins and compounds, applications, properties and processing. (176)

Electrochemically Refined Materials. Norton Co. Complete line of electrochemically refined refractory materials for industry. (173)

Precision Molded Thermoplastics. Plastic Molded Parts, Inc., 6 pp. Facilities available for Zytel and other thermoplastic precision moldings. (197)

Thermoplastic Molding. Plymouth Industrial Products Inc., 4 pp. Presents plastics molding processes and facilities for low cost molded parts. (174)

Corrosion Resistant Gasketing. Products Research Co., 5 pp, ill. Features, advantages and specifications of Chromelock corrosion resistant gasketing material. (175)

Carbon Graphite. Pure Carbon Co., Inc., 32 pp, ill, No. 52. Technical data on description, properties, applications and specifications of Purebon carbon graphite. (177)

Polyvinyl Chloride Coating. Quelcor, Inc., 4 pp, ill, No. 53A. Polyvinyl chloride coatings fused and flowed on metal for corrosion protection. (178)

Styrene Resins. Reichhold Chemicals Inc., Technical Bulletins Nos. 1, 2, 3, 4 and 5. Applications, characteristics, catalysis and mixing recommendations of Polylite polyester resins. (179)

Flexible Hose. Resistoflex Corp., 4 pp, ill. Includes chemical and physical properties and typical applications of Resistoflex flexible hose. (180)

Gasket Sheeting. Rogers Corp., 4 pp, ill. Describes a line of asbestos-elastomer material. (181)

Plastics. Sillcocks-Miller Co., 4 pp, ill. Applications of plastics as an alternate to hard-to-get metals. (182)

Cellular Rubber. Sponge Rubber Products Co., 20 pp, ill. Properties of specifications for, and test data on this firm's cellular rubber materials. (183)

Plastic Molding Presses. F. J. Stokes Machine Co., 8 pp, ill, No. 525. Describes complete line of Stokes automatic-semi-automatic, preforming and extrusion presses. (184)

Ceramic Laboratory Ware. Thermal Syndicate Ltd. Technical descriptions, specifications, prices of Vitreosil ware, said to be superior to porcelain in some uses. (185)

Molded Thermoplastics. Tri-State Plastic Molding Co., Inc. Folder describes this company's facilities for producing to order thermoplastics parts by injection molding. (186)

Molded and Extruded Rubber Parts. Tyer Rubber Co., 8 pp, ill, No. 1P52. Detailed information on various types of molded and extruded parts of natural and synthetic rubber. (187)

Plastisol. United Chromium, Inc., 4 pp, ill. Physical, chemical properties of Unichrome plastisol compounds used for coating, casting or molding. (189)

Finishes • Cleaning and Finishing

Sodium Nitrite. Allied Chemical & Dye Corp., Solvay Process Div., No. SP-23A. Sodium nitrite for corrosion resistance. (190)

To obtain literature appearing on these pages, please refer to easy-to-use reply card on pages 67 and 68

Hot Dip Galvanized Coatings. American Hot Dip Galvanizer's Association Inc., 16 pp, ill. Description of hot dip galvanizing process in industrial and consumer item applications. (191)

Coated Abrasive. Carborundum Co., Coated Products Div., 8 pp, ill, No. 2. Characteristics and applications of Resin Industrial Cloth, a new coated abrasive product for dry-belt grinding. (192)

Protective Coatings. Ceilcote Co., 8 pp, ill, No. C-150. Gives base formulations, chemical properties and adhesion characteristics of seven standard organic coatings. Includes simplified chart for selecting coatings, surface treatment, processes, etc. (193)

Flock. Cellusuede Products Inc., 12 pp, ill. Uses and method of application of decorator flock. Includes explanation of adhesive selection and application. (194)

High Vacuum Equipment. Consolidated Vacuum Corp. Price list of high vacuum equipment and accessories. (270)

Industrial Cleaning. Du Bois Co. Metal cleaning chart with folder on three-stage spray cleaning and a spray booth maintenance check chart. (195)

Wear Resistant Coating. Electrolyzing Corp., 16 pp. Detailed data on the Electrolyzing Process for increasing the life and efficiency of metal parts subjected to wear, abrasion and corrosion. (196)

Chemical Plating. General American Transportation Corp. Large illustrated folder. Description of Kanigen, a new type of nickel plating process requiring no electrical equipment. (198)

Insulating Varnish. Irvington Varnish & Insulator Co. General catalog on complete lines of insulating varnishes. Also contains a section "How to Use Insulating Varnishes." (199)

Colored Silicone Finishes. Midland Industrial Finishes Co., ill. Reprint interestingly discusses the application of colored silicone finishes. (201)

Belt Grinding. Minnesota Mining & Mfg. Co., 12 pp, ill. Describes the 3M method of belt grinding and finishing using coated abrasive belts as a means of highspeed grinding and finishing of flat or contoured surfaces. (202)

Metal Cleaner. Mitchell-Bradford Chemical Co., 1 p. Description of Magiclene #2 cleaners and degreasers. (204)

Coating for Zinc Surfaces. Neilson Chemical Co., No. 48-49. Describes Galvaprep, coating providing good adhesion of paint on galvanized iron, other zinc-coated surfaces. (205)

Metal Cleaner. Niagara Alkali Co. Pamphlet gives properties of Nialk Trichlorethylene, high quality metal-cleaning and degreasing agent. (206)

Metal Cleaners. Northwest Chemical Co., 4 pp. Chart for selecting proper cleaners for use prior to plating or organic finishing. (207)

Metal Finishing. Pelron Corp., 12 pp, ill. Description of metal cleaning phoshating, paint stripping compounds and spraybooth materials. (209)

Tar-Base Protective Coatings. Pittsburgh Coke & Chemical Co., Protective Coatings Div. Five bulletins give detailed information concerning Pitt Chem 100

Manufacturers' Literature

Series of tar-base protective coatings. (211)

Industrial Brushes. Pittsburgh Plate Glass Co., Brush Div., Dept. W-4, 3221 Frederick Ave., Baltimore Md. Case histories indicate economies available to users of Pittsburgh brushes. Request on company letterhead direct from this company.

Surface Coatings. Shell Chemical Corp., 32 pp, ill. Epon resins; physical properties, chemical properties, solubility and compatability formulas, data and reference tables. (213)

Corrosion Resistant Coating. Specialty Coatings Inc., Div. of Thompson & Co., 6 pp, ill. Examples of how Vinsynite Pretreatment was used in finishing six different types of metal products for good paint adhesion and corrosion resistance. (214)

Liquid Honing. Vapor Blast Mfg. Co., 4 pp, ill. Equipment for surface finishing by liquid honing, specifications and dimensions of equipment. (215)

Heat Treating • Heating

Cyclic Annealing. Ajax Electric Co., Inc., 4 pp, ill, No. 121. Explains cyclic annealing process and its advantages over regular annealing methods. (217)

Conveyor Furnaces. Harper Electric Furnace Corp., 4 pp, ill, No. 454. Describes mesh belt conveyor furnaces. Gives specifications and dimensions. (218)

Metal Baskets. Hoffman Co., 7 pp, ill. Describes this company's metal baskets, for use in such processes as heat treating, cleaning, dipping and plating. Price list included. (219)

Surface Hardening Stainless Steels. Lindberg Steel Treating Co., 24 pp, ill. Complete data on the Malcomizing process for surface hardening stainless steels. Seven case histories are included. (221)

Heat Treating. Misco Fabricators, Inc., 4 pp, ill. List of heat-resisting alloy and stainless steel process equipment. (222)

High Frequency Heating. New Rochelle Tool Corp., 16 pp, ill. Describes the principles of induction and dielectric heating. Includes typical specific applications of high frequency heating in welding, brazing and heat treating. (223)

Air Compressors. The Spencer Turbine Co., 12 pp, ill, No. 126-A. Performance curves, capacity tables and detailed descriptions of Turbo compressors for use in gas or oil fired heat treating equipment. (228)

Heat Treating. Stewart Industrial Furnace Div., Sunbeam Corp., 4 pp, ill. Monthly publication entitled *Metal Minutes* devoted to methods of heat treating and featuring a different installation each month. (229)

Liquid Carburizing Salts. Swift Industrial Chemical Co., 4 pp, ill. Complete data on Swift polytherm blended liquid carburizing salts for imparting a hard, wear resistant surface to steel. (230)

Heat Treating Furnaces. Industrial Heating Dept., Westinghouse Electric Corp., 38 pp, ill, No. B-5459. Complete description of Westinghouse furnaces—large and small, gas and electric. (232)

Heating Units. Edwin L. Wiegand Co., No. 50. Catalog describes this company's industrial heating units, giving specifications and features. (231)

Welding • Joining

Stainless Fasteners Specifications. Anti-Corrosive Metal Products Co., Inc., slide indicator. Identifies the type of fasteners specified by each A-N number pertaining to the stainless fasteners. Refers user to this company's catalog for more data. (234)

Fastening Pins. C. E. M. Co., 4 pp, ill. Advantages and examples of how Spirol Pins overcome the inherent shortcomings of fastening pins due to their spiral cross-section. (235)

Rivets. Champion Rivet Co., 48 pp. Specifications of small and large rivets and comprehensive tables of approximate weights. (236)

Weldment Assemblies. Continental Foundry and Machine Tool Co., 6 pp, ill. Advantages of large welded assemblies, typical applications, and production facilities available. (237)

Keying and Pinning. John Gillen Co., Inc., 4 pp, ill. Machined keys and pins for production assembly. (238)

Aluminum Fasteners. The Jacques Co., 8 pp, ill, No. 50A. Price list and specifications of this company's line of aluminum fasteners. (239)

Solder. Kester Solder Co., 80 pp, ill. Titled *Solder, Its Fundamentals and Usage*, this study of the industrial applications and uses of solder discusses fluxes, solders, equipment and production techiques. (240)

Induction Heating for Brazing. Lepel High Frequency Laboratories Inc., 8 pp, ill. Details on induction heating units for accelerated brazing of parts. (241)

Welding Nuts. Midland Steel Products, Inc., 4 pp. Self-locating nuts for faster assembly where nut is welded to plate. (242)

Rivets. Milford Rivet & Machine Co. A handy slide rule selector gives complete rivet specifications. (243)

Steel Bolts. Pittsburgh Screw and Bolt Corp., 12 pp, ill, No. 101. Complete data on high tensile steel bolts for structural points, including a research report and case histories. (244)

Nut Clip Fastener. Prestole Corp., 2 pp, ill, No. 751-A. Engineering and application data of a new heavy-duty nut clip fastener that rapidly assembles heavier gage sheet metal. (245)

Lock Screw Fasteners. Russell, Burdsall & Ward Bolt & Nut Co., 3 pp, ill. Features, advantages and dimensions of this company's spin-lock screws. (246)

Self-Locking Set Screws. Set Screw & Mfg. Co., 20 pp, ill. Illustrates and describes various types of standard and self-locking set screws with data on dimensions, prices, heads, points and materials. (247)

Brazing Alloys. United Wire & Supply Co., 3 pp, ill. Wire brazing aluminum for low temperature brazing of various metals and alloys. (251)

Resistance Soldering. Wasserlein Mfg. Co., Inc., ill, No. 105-D. Explains resistance soldering and includes operating instructions for using the Wassco Glo-Melt resistance soldering unit. (252)

Forming • Casting • Molding • Machining

Shell Molding. General Electric Co., Chemical Materials Dept., 28 pp. Demonstrates shell molding process for economical production of cast parts. (254)

Mold Heating Units. Improved Paper Machinery Corp., Plastic Molding Machinery Div., 1 p, ill. Specifications and descriptions of Models 1 and 2 mold heating and circulating units. (255)

Inspection • Testing • Control

Laboratory Reagents. Allied Chemical & Dye Corp., General Chemical Div., 40 Rector St., New York, N. Y., 264 pp, ill. Buyer's guide for use of laboratory reagents and chemicals. Includes grades, strength and maximum limits of impurities. Request direct from Allied on company letterhead.

Precision Optical Instrument. American Cystoscope Makers Inc. Features and typical uses of ACMI borescopes for precision inspection. (257)

Corrosion Control. Bishopric Products Co., 8 pp, ill. Properties of Lastiglas, a corrosion resistant, thermosetting, phenolic lining for tanks and piping. (259)

Photoelastic Stress Analysis. Eastman Kodak Co., Rochester 4, N. Y., 16 pp, ill, price 35¢. Booklet briefly describes photoelastic stress analysis as a method of solving problems of stress distribution. Write direct to Eastman on company letterhead.

Pocket Thickness Gage. Ferro Corp. Describes pocket size thickness gage, said to give good accuracy for measuring nonmagnetic coatings on ferrous surfaces. (261)

Surface Roughness Scale. Gar Precision Parts, Inc., 4 pp, ill. Low cost Microfinish Comparator made by electroforming for use in inspection, quality control, etc. (258)

X-ray Generator. High Voltage Engineering Corp., No. JR. New model Van de Graaff one-million-volt x-ray generator for heavy duty radiography on steel thicknesses up to 4½ in. (262)

Fatigue-Testing Machines. Krouse Testing Machine Co., 10 pp, ill, No. 46-B. Describes company's plate and sheet fatigue testing machines, including specifications and testing data. (263)

Radiography. Radium Chemical Co., Inc., 48 pp, ill. Details of radium radiography, explaining the nature of the equipment and method, recommended techniques and aids to interpreting results. (264)

Test Cabinets. Refrigeration Systems, Inc., Hudson Bay Div., 8 pp, ill. Illustration and descriptions of various types of test cabinets providing refrigeration, humidity and vibratory environments. Specification data given. (265)

Materials Controls. Remington Rand Inc., No. KD367. Describes Kardex system for keeping visible materials and parts inventories coordinated with production. (266)

Ultrasonic Thickness Gage. Sperry Products, Inc., 4 pp, ill, No. 3700. Description and basic theory of Reflectogage ultrasonic thickness tester and flow detector. (267)

Impact Tester. U. S. Testing Co., Inc., 2 pp, ill. Gives history, description and use of the SPI low temperature impact tester. (268)

For more information, turn to Reader Service Card, Circle No. 334

Materials
& Methods

February, 1955

One point of view

The priceless ingredient

In this day of discount houses, fair trade prices and many other factors which tend to distract the buyer, it becomes easy to confuse low prices and bargains. There is a vast difference and the difference is much more vital when the same terms of reference are applied to industrial goods.

Recently a visitor to our office was lamenting the sad state into which certain portions of the metal fabricating field had fallen. It was his feeling that many companies, who should know better, were making the sad mistake of buying on price alone. He was referring primarily to special types of work such as the high pressure piping and storage systems which are used by utilities, refineries and the process industries. Special fabrications for these industries could involve several hundred thousands of dollars, if not more, so the opportunity to save a few thousand dollars is quite attractive. But buying on price alone can be inviting failure, as many companies are now learning.

Shoddy workmanship and inferior materials, which are the usual twins which make unrealistically low prices possible, can often be disguised for a while. However, when they do become apparent the results can be exceedingly costly, if not ruinous. Not only do the materials require replacement, but the activity in which they function is usually halted until repairs can be made.

Our visitor made this point: Too often those responsible for placing contracts of this nature are not sufficiently trained in materials to recognize where pitfalls might occur. As a possible answer to the problem he suggests that specifications for the materials be developed by a technically qualified individual who knows what is needed, and why, and who also knows what can happen if the specs are not met completely.

Actually there are two methods of attacking the problem. The one just described is fine, and the other is summarized in the advertising slogan of a well-known manufacturer of pharmaceutical materials: "The priceless ingredient of a product is the integrity of its maker."

So when a low price seems attractive it might be well to investigate and learn whether the low price is due to the know-how of the bidder—and thus is a bargain—or whether it is a result of a corresponding reduction in quality.

T. C. Du Mond

Major fire losses *in metalworking plants such as this Chicago factory have increased 17 times in the last ten years.*

New materials, more complex processes, compound hazards in the metalworking field. So check for . . .

New Fire Hazards

by Theodore B. Merrill, Jr., *News Editor, Materials & Methods*

■ LARGE-LOSS FIRES in heavy and light metalworking plants have increased alarmingly in the last few years. At present, fires resulting in losses of a quarter million dollars or more are occurring 17 times as often as ten years ago. Such large-loss fires represent more than the destruction of a plant or a small company; higher insurance premiums punish all industry through higher fixed costs, and disrupted production schedules can compound the actual fire loss.

Why the increase?

The National Board of Fire Underwriters reports that part of the increase in large-loss fires is due to the greater concentration and value of metal-working equipment. Some new fire hazards have appeared in the last few years, but by far the greatest cause of increased fire losses is the presence of old fire causes in more hazardous configurations without a concomitant increase in preventive measures.

The hazards

Metalworking production frequently involves excessively large, unprotected areas in which a number of materials and processes are mixed together. Wood and some plastic materials used in conjunction with metalworking constitute a constant fire hazard, particularly in the many cases where plants are considered to be strictly concerned with non-combustible metals and lack automatic fire control systems. Flammable-liquid fires, metal dust explosions and maintenance fires from the use of sawdust to absorb oil waste continue to predominate as fire causes rather than new or unusual materials or processes more recently introduced. Increased use of, and greater mechanization of such processes as salt bath heat treating, quenching, electroplating and electropolishing are causing difficult control problems.

Among the most serious hazards in newer processes and operational techniques the National Board of Fire Underwriters includes:

1. Oil fog coolants and lubricating systems in machine tool systems. Even high flash point liquids are very flammable and sometimes explosive when finely atomized.

2. Higher machining speeds. Hotter metal chips may touch

off a fire in the coolant or within a greater radius of the cutting tool.

3. The increased use of metals such as magnesium, titanium, zirconium, which are flammable under some conditions when not handled properly.

4. Sodium-cooled dies for die casting.

5. More use of high pressure hydraulic equipment near hot metalworking operations. An accidental spray of hydraulic fluid can lead a fire many feet.

6. Powder metallurgy. Dust explosion hazards are increased as particle size is reduced.

7. Controlled atmosphere furnaces. Some controlled-atmosphere furnaces for heat treatment have inherent fire or explosion hazards. Industrial use of such equipment is on the increase, and should be paralleled by suitable precautionary measures.

8. Hot paint sprays in finishing.

9. Flammable adhesives and plastics for coating metals. Often flammable material is brought to the working area without increasing fire protection measures.

10. Oxygen and compressed fuel gases for flame hardening and surface cleaning.

11. Plastics (introduced as components, molding materials, etc.) in both metalworking and assembly operations carried out in plants that are protected strictly as metalworking operations.

12. Chemical descaling of metal parts and molds with molten hydride, nitrate, and caustic salt baths. Particularly dangerous if one bath is used for several different metals.

Fire and metals

The fire and explosion characteristics of metals are dependent on surface area and temperature as well as the basic chemical characteristics of the material and its environment. Most of the common metals present an explosion hazard when molten if they contact water. Secondary fires caused by spilled molten metal must be extinguished with care to avoid flooding the primary source of molten material, or causing an explosion of the spilled material.

It doesn't *have to burn to be worthless junk. This machine tool from the General Motors Livonia plant was warped, the steel was softened and parts were welded together.*

Almost all metal powders are combustible. Some are extremely pyrophoric when particle size is very small, and spontaneous ignition may occur in dispersed powder-air mixtures. Even such stable metals as iron are combustible in powdered form; a dust cloud of hydrogen-reduced iron particles will ignite if exposed to temperatures as low as 600 F.

Many metals present an extreme explosion hazard in powdered form if they are suspended in a dust cloud. Stamped aluminum powder can cause the most severe explosions of all metals in terms of pressure and rate of pressure rise. Magnesium powder is in the same class, and, on the average, magnesium dust explosions are more severe than aluminum. Many dust explosions in metalworking are progressive—a localized explosion occurs which stirs up dust collected on rafters, in dust collection systems, and in waste piles. A resultant secondary explosion is frequently more widespread and causes most of the damage. Since it is practically impossible to take any action to combat a series of dust explosions once they have begun, proper design, installation, cleanliness and maintenance of dust collection and disposal systems are absolutely necessary preventive measures.

Quite a few metals that are now showing up more often in metalworking are combustible in other than dust form and require special handling techniques. Very thin sheets of titanium, zirconium, and magnesium will burn if exposed to a direct flame. Aluminum, zinc and uranium powders will ignite below 1000 F. Potassium, sodium, cesium and lithium will ignite if heated gently in air above 500 F. Powdered or fine chips of magnesium burn more violently when

damp than dry.

Metals are not only hazardous because of oxidation properties. Reactions with other common substances may cause an intensification of fire or explosion. Potassium, lithium, cesium and sodium will react with water at room temperature. Dusts of aluminum, magnesium and zinc will decompose water and might cause an oxyhydrogen explosion if not vented. Glowing iron dust reacts strongly with water. Manganese, titanium and zinc will evolve hydrogen from water at temperatures over 300 F. Caustic soda or potash will generate hydrogen if in contact with aluminum, titanium and zirconium. Most strong acids will evolve hydrogen when in contact with common metals.

Metals processing

Molten, fused-salt baths can be dangerous fire and explosion hazards in metalworking if not handled with proper caution. Molten salt temperatures run as high as 2400 F and, like molten metals, can cause secondary fires. The National Board of Fire Underwriters lists five main causes of fire, explosion and gassing accidents:

1. Steam explosion and spattering. Any water in contact with molten salts will cause a steam explosion, and the salts will start secondary fires and cause serious injury to personnel. Sources of water causing accidents include: carry over water from quenching tanks; leaks or drips from overhead pipes, roof, or condensation; entrained moisture in compressed air used to agitate bath; sprinklers or foam fire protection equipment or direct streams from hoses; and from spilled food containers placed on ledges by workmen to warm their meals.

2. Air entrapment in work pieces may rupture work with a violent explosion and spattering.

3. Reaction explosions with combustibles and magnesium. Carbonaceous material will cause an explosion in molten nitrate baths. Aluminum alloys containing magnesium may explode violently at temperatures in excess of 1000 F. Magnesium parts accidently mixed with aluminum batches will cause explosions, and safeguards are necessary in plants using both light metals to insure that the metals are identifiable and separate at all times.

4. Overheating and thermit reactions. Overheating due to electrical control failure has caused accidents when salt baths are left unattended at idling temperature. Iron oxides accumulating in the bottom of the bath can cause localized overheating, and if an aluminum alloy contacts the sludge a thermit reaction may occur resulting in a violent reaction, pot rupture, and explosion.

5. Improper disposal of waste nitrates. Active salts mixed with residues can cause explosions and fire.

Molten salt bath fires should never be wet with water, foam, or carbon tetrachloride type extinguishers. Sand or proprietary dry powders should be used. Oil and quench tank fires not involving molten salts can be extinguished with fixed water sprays, foam, or carbon dioxide type extinguishers. Because quench tanks and salt baths are usually in close proximity, it is necessary to have instructions for extinguishing fires clearly mounted and warnings on both tanks and extinguishers.

Standards and hazard surveys of the metalworking industry are available from the National Board of Fire Underwriters, 85 John St., New York, New York, the National Fire Protection Assn., Boston, Mass.; The Factory Insurance Assn.; and various industry associations.

Safeguards

Frequent inspection and review of equipment, techniques and materials by experienced fire inspectors should be a must for any metalworking operation. Local fire departments should be consulted concerning the adequacy of water supply and availability of chemicals to fight any type of fire that might occur in a given plant.

It is important to realize that fire hazards are not static. They change when different materials or methods are introduced in a plant. New casting techniques, high speed cutting tools, hydraulic equipment, heat treatment and metal finishing, or even a rearrangement of floor plan may alter the fire hazards in a given plant to the extent that fire hazards are compounded. Lewis A. Vincent, General Manager of The National Board of Fire Underwriters, warns, "The modernization of many metalworking establishments is bringing about a complex technological transformation. Many operations are changing rapidly in terms of hazardous auxiliary processes and mixed occupancies, with more serious loss potentials brought about by larger building units, higher inventories and increasing values. The changes are not limited to the giant mass producers, but involve as well the greater number of smaller production plants. Lack of preparedness can mean the difference between survival and total destruction. Existing standards and codes are essential guide posts to intelligent planning and should be adapted to requirements of all plants."

Concerning metalworking plants, M. M. Braidech, Research Director for the NBFU, claims that many metalworking plants are protected in terms of the incombustibility of the metal that is worked—i.e., "iron won't burn"—and not in terms of the many secondary fire hazards, fire damage possibilities and new materials allied with metalworking. Braidech believes that there is serious need for increased cooperation among the metalworking industry, fire protection engineers, designers and consultants. The statistics of fire losses in recent years back up his contention.

New Polyester Felt

Is better than conventional wool felt in—

- *Strength*
- *Heat Resistance*
- *Chemical Resistance*

A NEW MATERIALS PREVIEW

Dacron felt *comes off the machine in Du Pont's new Textile Research Laboratory at Chestnut Run, near Wilmington, Del.*

Wool felt, available in a wide range of quality and density, is suitable for many different mechanical applications. Broadly classified, these include friction uses, cushioning, sealing, wicking, filtering and insulating. Despite its usefulness, however, conventional felt is rather limited in its resistance to heat at temperatures above 250 F and in its resistance to chemical environments.

The properties of wool felt are often improved by impregnating, laminating or "proofing" it with other materials, including synthetic resins. Completely synthetic felts consisting of thermoplastic fibers held together by controlled fusion are being used in chemical filters.

Now, however, a completely synthetic heat-resistant felt has been developed by Du Pont. The new material consists of Dacron polyester fibers that have been combined by a special process to produce a structure similar to that of wool felt.

Tests indicate the polyester felt out-performs wool felt 3 to 1 in breaking strength, 2 to 1 in splitting resistance and 16 to 1 in retention of strength after two days in moist air at 350 F. It has good resistance to acids and alkalis, high deformation recovery, good abrasion resistance, good dimensional stability and good uniformity. It is also nonswelling, unaffected by mildew and microorganisms, and it can be easily cleaned.

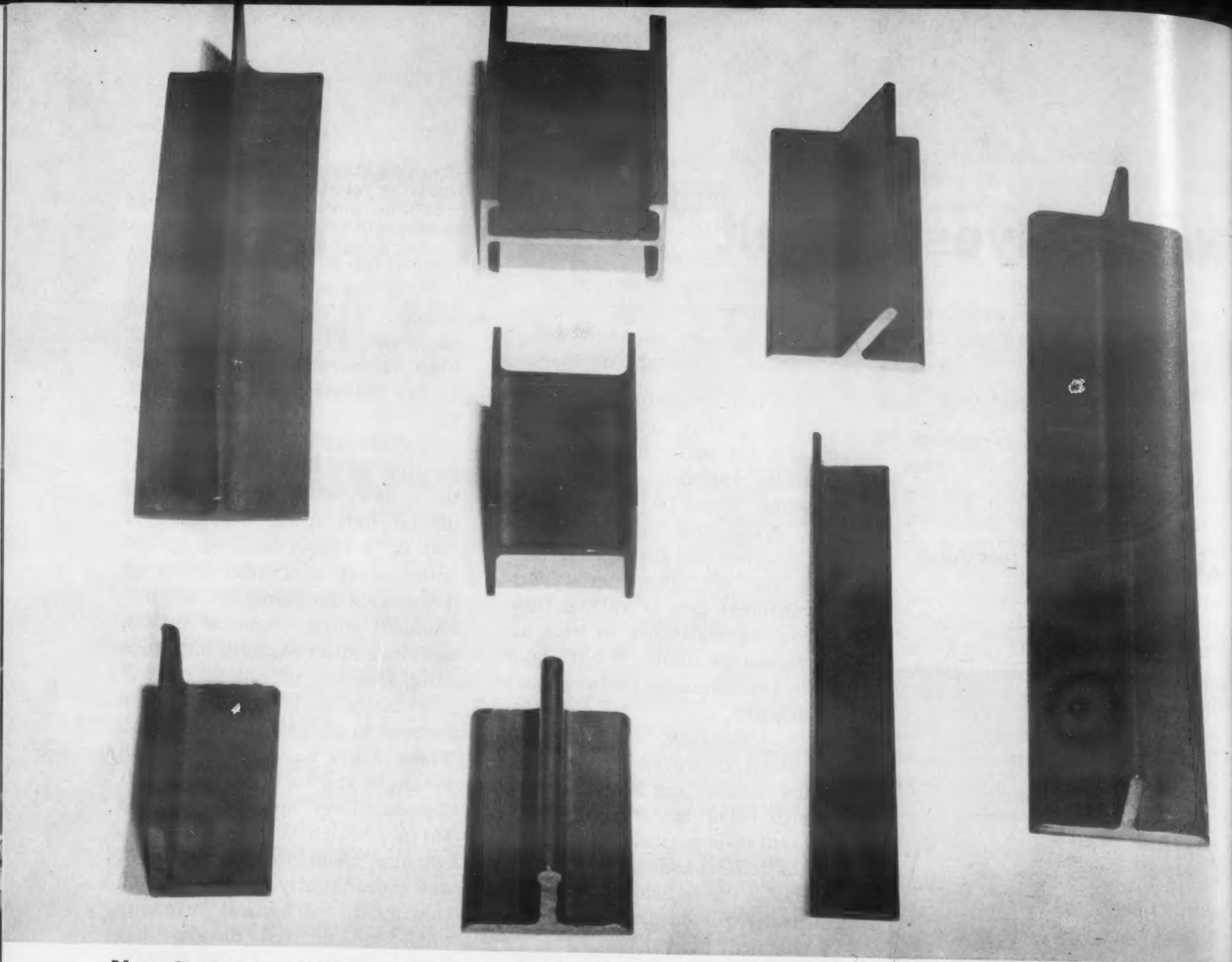
Detailed data on these properties are not yet available for publication. However, the following figures are claimed to be typical of the differences between wool and Dacron felts of equivalent densities:

	Wool	*Dacron*
Breaking strength, psi	400	1195
Splitting resistance, lb/2-in. width	18	34
% strength retained after 2 days in moist air at 350 F	5	80

First use of the new material is likely to be in the filtration of corrosive liquids and gases at high temperatures. Field tests in dry filtration are now under way.

A synthetic felt has been made possible only by the development of a new felting process. The official Felt Assn. definition of felt is "a fabric built up by the interlocking of (wool) fibers by a suitable combination of mechanical work, chemical action, moisture and heat, without spinning, weaving or knitting. . . ." Previously, only wool and fur seemed to be adapted to felting. These fibers have the ability to entangle and to permanently interlock. They also have a scaly surface which acts as a ratchet, causing them to become more and more tightly entangled with continued mechanical working until the desired density has been attained.

The synthetic fibers have neither the interlocking tendency nor the surface which are the basis of conventional felting techniques. However, the Du Pont process achieves the same result in a different way. A batt of pre-stretched Dacron fibers (carded like cotton batting) is run through a needle loom where barbed needles pick up fibers from one side of the batt and carry them through the other side, thus stitching the material together with its own fibers. The resulting material is then compacted by exposing it to dry heat at 300 to 400 F or by immersing it in boiling water. The fibers shrink 30 to 50% when exposed to heat, and actual shrinkage can be controlled to produce felts of any density desired. The degree of fiber shrinkage, the amount of needle punching and the weight of the carded batt determine the properties of the polyester felt.



Aircraft structural shapes *extruded from titanium alloys. H-section is MST 3Al-5Cr; others are RC-130B.*

Titanium Alloy Extrusions Now Available

Titanium alloys can be hot extruded as readily as steel. Properties are like those of forgings and hot rolled bars.

by G. A. Moudry, *Harvey Aluminum Division*

■ HARVEY ALUMINUM IS PRODUCING standard structural shapes in the titanium alloys, Rem-Cru RC-130B, Mallory-Sharon 3Al-5Cr and the 3Mn-complex alloy developed by Battelle and the Air Force, to standard AN aluminum extrusion tolerances. Metallurgical and mechanical properties are guaranteed from surface to center and end to end, identical with aluminum practice. Extruded bars and rods are under development for fabrication into fasteners.

Some of the shapes which have been produced are shown in an accompanying photograph. They include a Tee with leg thicknesses of 0.215 and 0.315 in. and an H-section with 0.100-in. leg thickness.

The mechanical properties of

extruded titanium alloy shapes are generally similar to those reported for forgings and hot rolled bars of the same alloys. Typical ranges for two of the alloys are:

Alloy	*Yld Str, 1000 psi*	*Ten Str, 1000 psi*	*Elong % in 2 in.*
RC-130B	125-130	145-150	10-11
MST 3Al-5CR	130-150	150-170	7-9

The inherent tendency of titanium to alloy with most known materials at elevated temperatures makes time at temperature an important factor. Herein lies one of the principal advantages of extrusion. The cycle is completed in a few seconds.

Methods have been developed by Harvey for the extrusion of cast billets. These eliminate preliminary break-down operations with multiple exposure to air at high temperatures and resulting surface contamination. Heating to the extrusion temperature in controlled atmosphere furnaces prevents changes in the quality of the billet resulting from oxygen and nitrogen pick-up. Since working the metal is conducted in a closed container, contamination is avoided during extrusion also. As a result, the product leaving the extrusion press has the same composition as the billet. Titanium alloys are not difficult to extrude and they fill the extrusion dies well. Pressures required are slightly higher than those necessary to extrude steel but the temperatures are lower.

An advantage of extrusion is the production of shapes having surfaces free from rolled-in scale and slivers. During extrusion, plastic flow occurs within the billet, and dies are designed to block off entry of material adjacent to the container wall. Thus, the surface of the billet is retained in the butt and does not enter the die. However, it is necessary to straighten extruded shapes to obtain satisfactory dimensions such as bow and twist tolerances. This is accomplished by hot stretching.

In addition to the actual mechanical aspects of producing titanium extrusions there are metallurgical aspects which require consideration. Among these are segregation, section size or extrusion ratio and working temperature. Alloy segregation is dependent on ingot inhomogeneity and is affected by various hot working methods only to the degree that the ingot structure is broken down. Extrusion has an advantage since the reduction in area is usually high and the process blends the plastically flowing metal and lends to produce a more homogeneous structure.

When the work of extrusion is done completely within the beta phase field, the ultimate grain size is a function of the degree of reduction. Higher extrusion reductions result in finer grain. When the work of extrusion is done in the alpha plus beta phase field, the distribution and size of the alpha stringers depend on the degree of reduction. The greater the reduction, the finer the alpha stringers.

In addition to the straightforward effect of the extrusion ratio and section thickness on degree of grain refinement, the effect on cooling rates is less predictable. The problem, then, resolves itself about the heat treatment response of the specific alloy. In fact, it is desirable to think of the extrusion process as a heat treatment cycle, starting at the time the billet is heated for working, and ending when the extrusion has cooled to room temperature. During extrusion, the total reduction from the billet to final extruded shape takes place, essentially, at one temperature. Forging and rolling differ because reduction occurs over a range of temperatures.

If extrusion is performed within the beta field, the principal effect of temperature is on the beta grain size; the higher the temperature, the larger the grain. Although the beta grain size is refined somewhat during extrusion, large beta grains do not re-crystallize to yield grains as fine as those resulting if an initially fine grain beta is used.

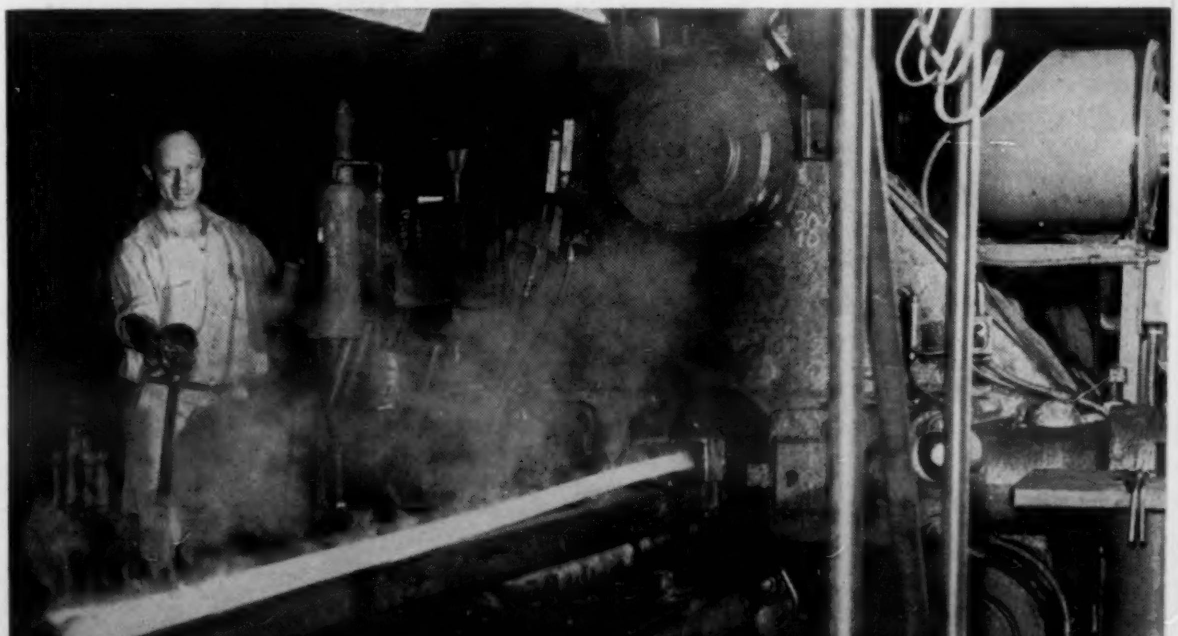
If extrusion is performed at a temperature within the alpha plus beta phase field there are two important effects:

1. The relative percentage of alpha and beta present at the time of extrusion is dependent on the temperature; the lower the temperature, the larger the percentage alpha in equilibrium with beta.

2. The composition of beta is dependent on the extrusion temperatures. Lower temperatures result in a lower percentage of beta, but this beta is higher in alloy content and is more stable during subsequent cooling.

The production of high quality extruded shapes requires recognition of the variables involved, judicious selection of operating procedures, and enforcement of rigorous quality control measures.

Extruding *an aircraft structural Tee-section of RC-130B at a temperature of 1600 F.*

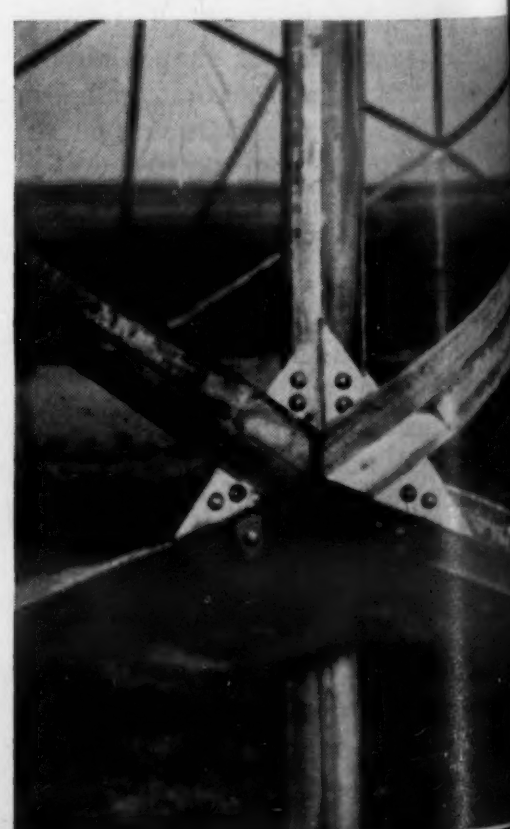


Materials at Work

New and old materials in unusual applications

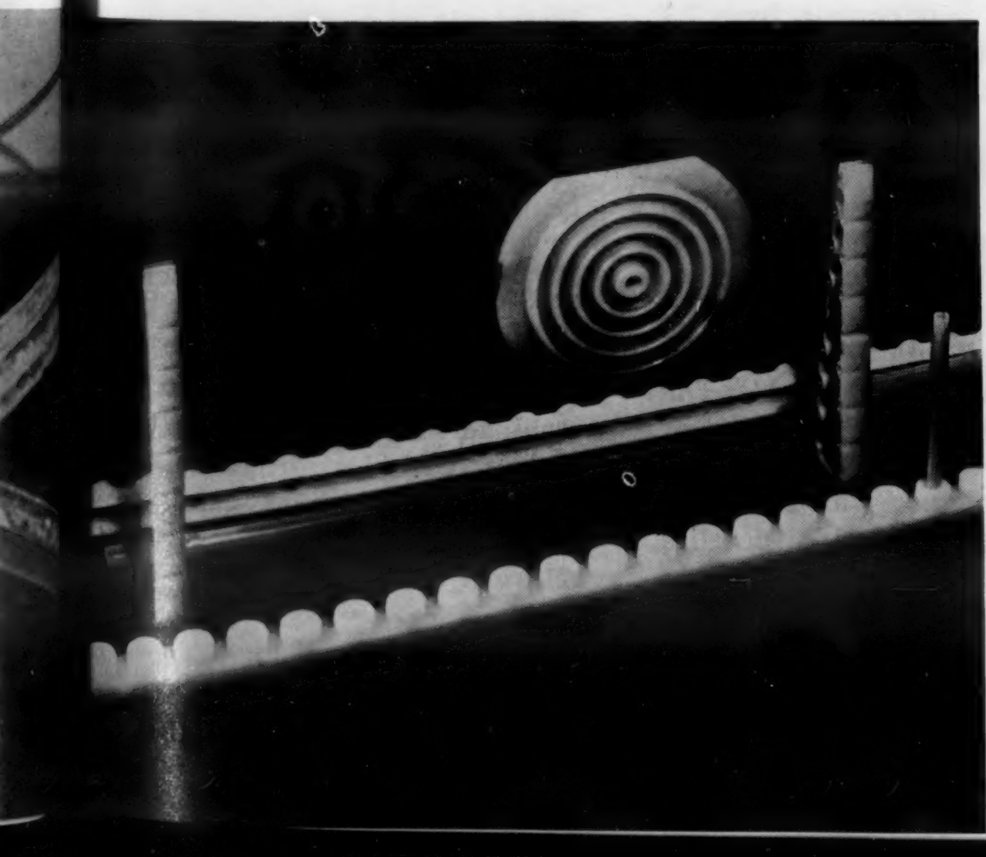
MAGNESIUM HANGAR CAN BE FLOWN AWAY The use of lightweight magnesium extrusions in this geodesic dome hangar permits a Marine Corps helicopter to pick up its own hangar and fly away with it. The shelter was designed by Buckminister Fuller at MIT and built by the Marine Corps.

It is made up of 60 diamond shaped panels and held together with 360 bolts. The present cover consists of five panels of vinyl-coated cotton duck. In order to reduce the weight of the cover, a new one is being made of vinyl-coated glass cloth. Total weight of the shelter at present is 1200 lb.

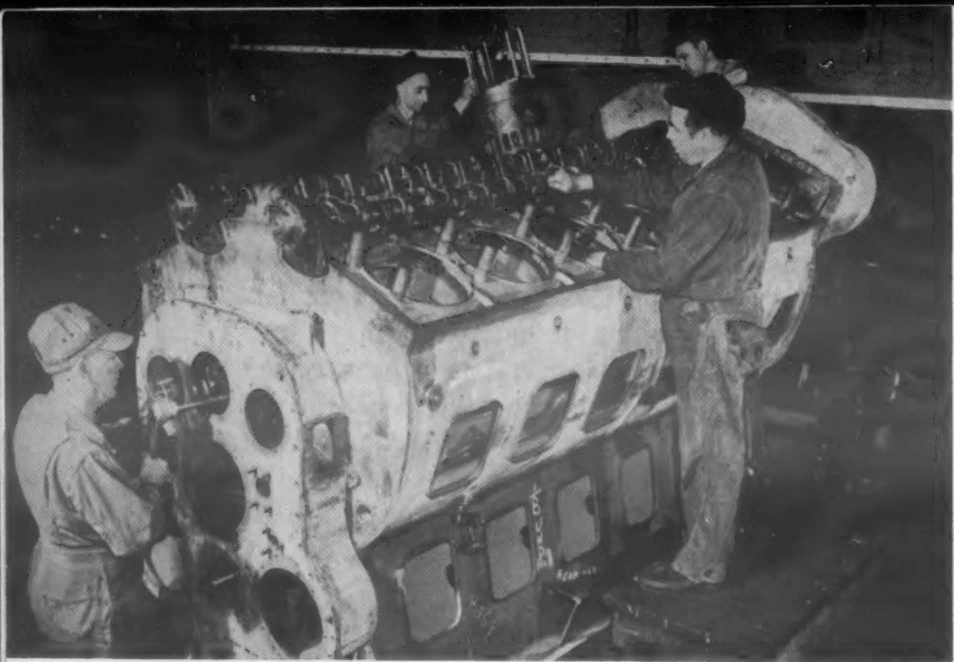


ZINC DIE CASTING CUTS PART COST An 80% cost reduction is reported by the manufacturer of this mounting rod used by Western Electric Co., for mounting resistances and coils on telegraph supply fuse panels. The mounting rod is presently being die cast in one part in Doler Zinc #3 alloy. The old method involved machining from round brass rod. As a die casting, the rods are produced in a two cavity die at the rate of about 35,000 per 40-hr week by the Doehler-Jarvis Corp. The only subsequent operations required are trimming, chasing the small diameter thread, facing the end and capping the cast hole.

TITANIUM SLASHES WEIGHT OF HUCK STUMPS Huck stumps made from C-130 AM titanium alloy, when substituted for high strength steel alloy stumps, result in a 40% reduction in weight without sacrifice in strength, according to Northrop Aircraft, Inc. These titanium fasteners, manufactured by the Huck Mfg. Co., are being produced in configurations identical to the steel stumps now in production, and are presently being evaluated for use by Northrop.



PLASTICS CUTS WEIGHT OF AIR FILTER Sixty parts molded of Du Pont's Zytel nylon are used in each unit of an electronic air filter produced by American Air Filter Co., Inc. They are said to reduce the weight of the filter and to minimize danger of breakage. Though the unit functions at a 12,000-v potential, actual current flow is around 20 milliamps which was sufficient to char other materials tested, and the resulting carbon deposits formed paths for short circuits. Nylon's high resistance to corona discharge is said to have eliminated this problem. The parts are molded by G-E's Plastics Div.



Cylinder liner *of gray iron being installed in a railroad diesel engine. (New York Central System)*

Alloy cast iron punches *are used in hot-forming airplane propeller cams from SAE 2512 steel at Wyman Gordon. (International Nickel Co.)*

Try Gray Irons

for High Temperature Service

You may find, like many others, that these low-cost irons will satisfactorily meet your service requirements.

by John L. Everhart, *Associate Editor, Materials & Methods*

■ Among the most valuable and least expensive materials for service in the moderate temperature field is gray cast iron. This fact is frequently lost sight of in the search for materials to serve in this range, but gray iron has a record of satisfactory service over many years in a number of industries. Applications include locomotive, diesel and marine engine parts, steam and oil pumps, process industry equipment, furnace parts and kettles.

Gray cast iron is a term covering a series of iron-carbon-silicon alloys having in common mainly the characteristic gray fracture which results from the presence of free graphite. These materials range from irons with tensile strengths of 20,000 psi to high strength alloy irons with strengths over 60,000 psi.

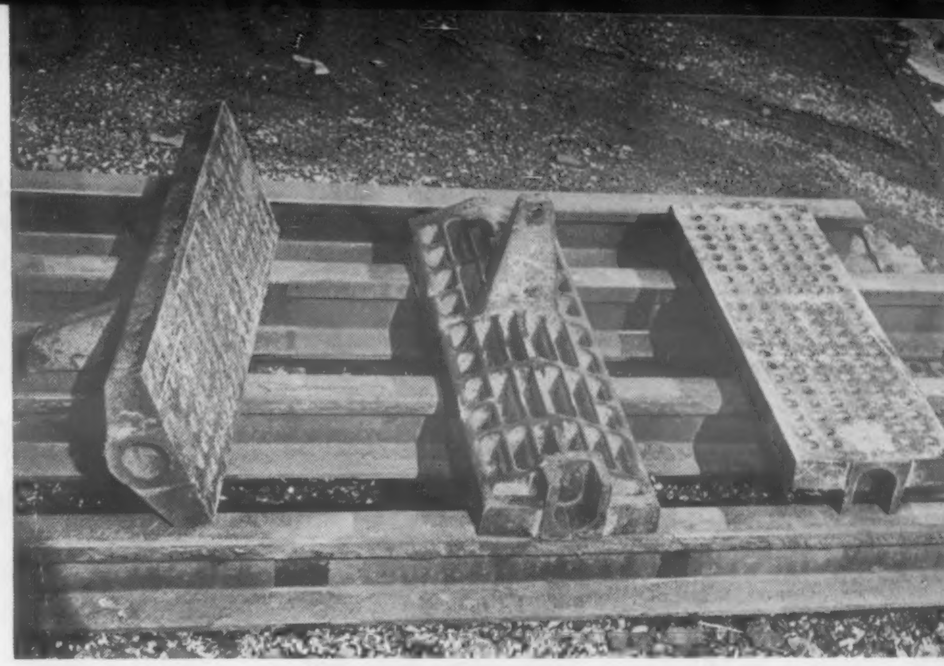
The term gray iron covers irons that may contain from 2.7 to 3.6% carbon and 1.25 to 3.0% silicon. Alloy irons are gray irons to which sufficient alloying elements are added to improve or modify the properties which can be obtained in common irons. The addition rarely exceeds 2% of any one element and frequently the total alloy addition is no greater than 2.5%. The composition and processing of these irons are adjusted to obtain a structure which is composed largely of fine pearlite with graphite flakes randomly dispersed throughout. There are, however, gray irons which contain sufficient alloying additions, usually of nickel, to cause the retention of austenite as the matrix material at room temperature. (Not discussed.)

The as-cast tensile strength of gray irons can be increased only by 1) adjusting chemical analysis to reduce the quantity of free graphite, 2) changing the size and distribution of the graphite flakes, and 3) strengthening the matrix by the addition of alloying elements.

In modern foundry practice, inoculation is increasing in popularity as a means of improving gray iron. Inoculants, such as ferrosilicon, are added in the ladle of molten metal to prevent the formation of primary carbides and to promote the formation of normal or randomly distributed graphite flakes. Use of inoculants provides an effective method of obtaining the maximum properties for a given application. They permit utilization of lower carbon equivalent irons and increase the uniformity of structure and properties.

For elevated temperature service, chromium is probably the most important of the alloying elements. This element is a stabilizer of carbides and the complex carbides formed do not break down readily at high temperatures. Therefore, growth is retarded and the irons have in-

Lead melting pot *produced by the Atlantic Foundry Co. from alloy cast iron to obtain increased resistance to scaling, distortion and thermal shock. (International Nickel Co.)*



Firebox grates *for Louisville & Nashville locomotives produced from 1% nickel-1% chromium alloy iron have three times the life of those produced from unalloyed gray iron. (International Nickel Co.)*

creased resistance to oxidation. Chromium additions also improve elevated temperature mechanical properties of the irons because of the stabilizing effect on the structure.

Molybdenum is a mild carbide former and assists in the retention of high temperature strength. On the basis of the few creep tests which have been reported, molybdenum appears to impart the greatest creep resistance of the alloying elements. However, it does not sufficiently retard growth and, therefore, is frequently used in combination with a stronger carbide stabilizer such as chromium. Vanadium is also a carbide former and is effective in retarding growth and reducing distortion.

Nickel is a graphitizing element. In order to retard growth, silicon content must be reduced, chromium must be added, or the nickel must be present in rather large quantities. In amounts sufficient to produce an austenitic structure, nickel is effective in increasing creep resistance. However, this material is in the class of high alloy irons. Copper is a graphitizer and its effect on the alloy is more pronounced in combination with other elements.

Specifications

Gray cast irons are generally specified by mechanical properties rather than by chemical composition because different foundries may employ different methods and compositions to produce materials having the same properties.

In ASTM designation A278, seven classes of gray iron are specified to cover requirements of pressure castings for elevated temperature service. These classes, ranging from 20,000 to 60,000 psi minimum tensile strength, are coded by numbers indicating the strength; thus, No. 20 indicates the 20,000 psi class. Only the three top classes, 40, 50 and 60 are designated as suitable for service above 450 F and an additional requirement is a stress-relief heat treatment. Chemical composition is subordinate to properties in these alloys, but maximum carbon equivalent is 3.8% for service above 450 F. Carbon equivalent = Total carbon + 0.3 (silicon + phosphorus). Alloying elements may be used to stabilize the structure or to facilitate development of desired properties. Common alloying elements suggested for this purpose are chromium, copper, molybdenum, nickel and vanadium and any combination can be used.

The ASME code for unfired pressure vessels sets maximum allowable stresses for cast iron based on classes similar to those covered in ASTM designation A278. The code states that the design pressure for vessels constructed of cast iron shall not exceed: 1) 160 psi at temperatures not greater than 450 F for vessels containing gases, steam or other vapors, 2) 160 psi at temperatures not greater than 375 F for vessels containing liquids, 3) 250 psi for liquids at

Glass pressing equipment *of nickel chromium cast iron. (Corning Glass Works and International Nickel Co.)*

temperatures less than their boiling point at design pressure but not exceeding a temperature of 120 F, and 4) 300 psi at temperatures up to 450 F for closures which do not form a major part of the pressure vessel. However, vessels constructed of stress-relieved material conforming to classes 40, 50 and 60 can be used for design pressures of 250 psi at temperatures of 650 F if the walls are uniform in thickness. This code does not permit the use of cast iron vessels, as containers for poisonous gases or liquids or flammable substances.

The ASTM has also designated three classes of gray iron for elevated temperature service under conditions in which pressure is not involved. The classes are specified in Designation A319 by carbon equivalent and the basic classes can be further modified with specified chromium contents. In addition all classes can be modified with such elements as copper, molybdenum, nickel and vanadium in any combination to increase strength or resistance to oxidation and surface deterioration. The specifications are general and cover cast irons normally used for non-pressure service up to 1400 F.

Properties

Temperature can affect cast iron in two ways: 1) deterioration caused by chemical or structural changes, or 2) changes in mechanical properties. The former results in dimensional changes accompanied by loss of strength and an increase in brittleness. The latter is a phenomenon common to all materials.

The permanent increase in volume which can occur in gray iron subjected to cycles of heating and cooling is called *growth*. In unstabilized iron, growth is directly related to the maximum temperature reached and the number of heating and cooling cycles involved. In extreme cases, gray iron has been known to increase as much as 50% in volume although this is not a common phenomenon.

Growth produces a permanent increase in dimensions and can cause severe loss in strength and increased brittleness. Because of these effects, plain gray irons are frequently limited to a top temperature of about 850 F unless the service is not particularly critical. Under ordinary service conditions, growth rarely occurs at temperatures much below 1000 F in well-made irons of proper analysis. On the other hand, certain corrosive agents such as superheated steam can cause serious growth at lower temperatures. Thus, each application must be studied individually.

To control growth, unalloyed or low alloy gray iron should be held to medium carbon contents with a maximum carbon equivalent of 3.9%. Silicon content should be low. For service up to 450 F, the minimum strength should be 35,000 psi and this should be increased progressively with increase in temperature. The use of small quantities of alloying elements to stabilize the structure is also advisable at higher temperatures.

An investigation on the effect of such small alloying additions has shown that chromium is the

SOME GRAY IRONS AND THEIR HIGH TEMPERATURE USES

Application	Nominal Composition, %								Ten Str, psi	Remarks
	T. C.	Si	S	P	Mn	Ni	Mo	Cr		
UNALLOYED GRAY IRON[1]										
Automotive Pistons	3.35	2.25	0.10	0.15	0.65	—	—	—	—	
Automotive Piston Rings	3.50	2.90	0.06	0.50	0.65	—	—	—	—	
Kettles and Pots	3.50	1.15	0.07	0.10	0.80	—	—	—	—	
Pots for Handling Caustic Soda	3.60	1.00	0.20	0.07	0.75	—	—	—	—	
ALLOY GRAY IRON[2]										
Uniflow Steam Engine Cylinders	2.90–3.10	1.4–1.6	—	—	0.80–1.00	1.25–1.50	0.40	0.50	50,000 min	High strength and wear resistance; thermal stability to 800 F
Automotive Cylinder Blocks	3.10–3.40	2.15–2.40	0.10	0.20	0.50–0.90	—	—	0.30–0.90	35,000–45,000	Wear resistance at elevated temperatures
Automotive Cylinder Heads	3.00–3.30	2.00–2.50	0.10	0.20	0.50–0.90	—	—	0.20–0.65	35,000–45,000	Wear resistance at elevated temperatures
Diesel Engine Cylinder Liners	3.10–3.30	2.10–2.30	0.10–0.13	0.15–0.20	0.70–0.90	0.60–0.80	0.60–0.80	—	46,000–54,000	Wear resistance at elevated temperatures
Steam Turbine Control Valves for Superheated Steam	3.00–3.20	2.40–2.50	0.05–0.10	0.15–0.25	0.65–0.85	—	0.70–0.80	—	37,000–42,000	High steam temperatures—life 18 months
Lead Pots and Kettles	3.20–3.40	0.90–1.40	—	—	0.55–0.80	1.50–2.00	—	0.60–1.00	35,000–40,000	Growth and crack resistance
Grate Bars, Furnace Liners	3.00–3.50	1.75–2.25	0.14	0.40	0.50–0.80	—	—	0.80–1.25	30,000–45,000	General service to 1400 F
Grate Bars, Stoker Service	3.20–3.60	1.40–1.60	0.04–0.10	0.15–0.40	0.60–0.80	1.15–1.75	—	0.50–0.75	32,000–35,000	Resistance to warping at moderately elevated temperatures
Tube Supports for Low Temp. Range of Petroleum Cracking Still	3.00–3.20	1.00–1.25	0.10–0.12	0.15–0.25	0.60–0.70	1.40–1.60	—	0.60–0.80	40,000–45,000	Resistance to warping and sealing. Excellent condition after 4-yr service
Girders for Blast Furnace Stoves[3]	2.90–3.20	1.75–2.00	0.12	0.20	0.75–1.00	1.00 min	0.35–0.50	0.30–0.50	50,000	Suitable for service at 800 F

SOURCE:
[1] *National Metals Handbook, 1948 ed.*
[2] *Alloy Cast Iron Handbook, AFA.*
[3] *Jour. Iron & Steel Institute, Vol. 155 (1947), p 136.*

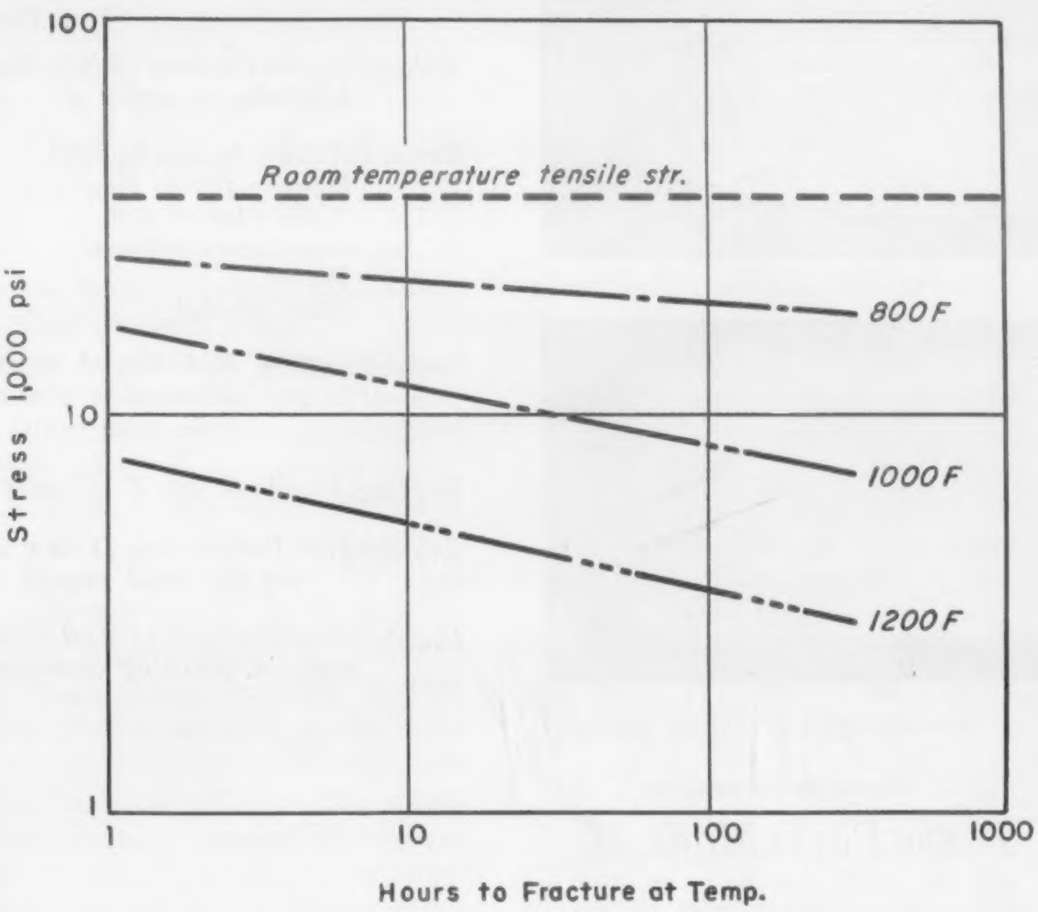
most effective growth inhibitor while vanadium, boron and copper are progressively less effective, in the order named. Growth starts at about 1000 F and the rate increases markedly at 1600 F. A chromium content of about 1% retards growth to about 1400 F. Irons showing the greatest growth, also showed the greatest loss in strength and hardness.

Investigations of the effects of temperature on the mechanical properties of gray iron have been somewhat hampered by the variety of materials which are included in this category. However, some effects seem to be pretty well established as applicable to most gray irons.

Short time elevated temperature tensile tests show that there is little loss in strength up to about 800 F. However, at higher temperatures, loss in strength is rapid. In one test, a cast iron which had retained its room temperature tensile strength to 800 F, lost 60% at 1100 F. Fatigue strength also remains practically constant up to 800 F but decreases sharply above that temperature. Gray cast iron does not seem to be notch sensitive at elevated temperatures.

This phenomenon of loss in strength above 800 F may possibly be correlated with structural changes. In extended service at temperature, decomposition of the pearlitic matrix in common gray iron starts at about 800 to 850 F and increases in rate at higher temperatures. In one test, holding at 1050 F for 500 hr caused the complete decomposition of pearlite. In another test with special alloy iron, little change resulted. Tests at room temperature after long-time heating at elevated temperatures show that the mechanical properties deteriorate in common irons held at temperatures above 800 F.

Creep data are not plentiful. Available information indicates that a gray iron having a carbon equivalent of 3.9% or less can sustain loads of 10,000 psi



Stress-rupture data for a low alloy gray iron. Constant load at temperature applied until failure occurred. Tyical elongation at fracture, 2 to 3% of total.

at 750 F without exceeding a creep rate of 1% in 10,000 hr. This figure is probably conservative since some tests have indicated that this rate would not be exceeded greatly at 850 F.

Applications

Many varieties of gray iron are used at elevated temperatures and no one composition can be specified for any application. Some typical compositions for various uses are included in an accompanying table.

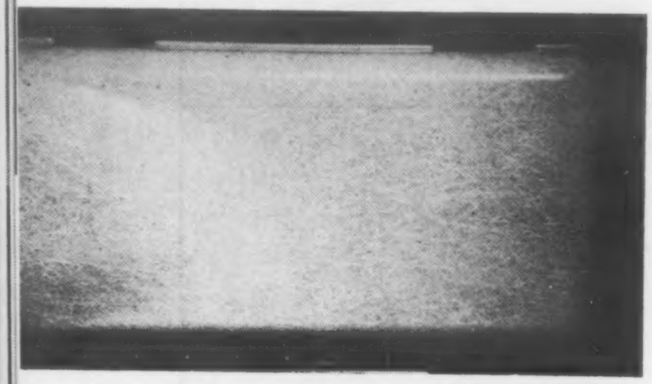
As pointed out previously, both the ASTM and the ASME have set a limit of 650 F and 250 psi for cast iron in pressure service and many codes follow their lead. This has undoubtedly restricted development of cast iron for elevated temperature service. Long time applications of common gray iron in steam engines at 750 F and 250 psi pressure indicate that the codes are extremely conservative. Further, internal combustion engines operating generally at 750 F but reaching a maximum of 1000 F have functioned satisfactorily for long periods even though there is a marked temperature gradient because of external surface cooling.

Some reports of service life of gray iron of unspecified composition indicate the value of this material. In the range 450 to 600 F, aircraft piston rings last 20,000 hr, and locomotive and diesel engine parts average over 20-yr service.

In the 600 to 750 F range, autoclave inserts, 8 yr, and locomotive steam piping, 10 yr.

In the 750 to 1000 F range, reports have indicated that diesel engine exhaust valves, furnace tuyeres and hearths and locomotive grate supports have service lives of 5 to 15 yr while lead and zinc melting kettles range from 2 to 10-yr service.

Above 1000 F, hot forming dies have produced from 4000 to 10,000 parts per grind, furnace parts such as dampers and grates up to 6 yr and diesel engine heads up to 3 yr.



How Parts Were Made

Glass: *Owens-Corning Fiberglas M503 mat, treatment 18 (melamine-bonded), ¾ oz/sq ft*

Resin solution (parts by wt.):

Melmac 405 or Resimene 814	*100*
Solka Floc	*10*
Guanidine carbonate	*0.5*
Water	*65*
Ethyl alcohol	*10*

Impregnation: *Mat dipped in resin solution and squeezed through rolls adjusted to give wet wt 4.9 times dry mat wt (for 70/30 resin-glass ratio)*

Drying: *10 min at 260 F in Lanly forced air oven (volatiles avg 8% by wt)*

Molding: *5 laminations (1 lb 6 oz charge for helmet); 10 min at 200 psi, 310 F; mold gassed twice, 20 and 30 sec (flow avg by wt)*

Mold: *Chromium-plated steel with telescoping pinch-off (0.093-in. telescope, 0.001-in. pinch-off clearance)*

These Parts Made of

Melamine-Glass

Laminated at Low Pressures

by L. M. Chellis, *International Business Machines Corp.,**

W. R. Graner and H. J. Stark, *Bureau of Ships, Dept. of the Navy*

**Formerly with Auburn Button Works*

■ ALTHOUGH melamine-glass laminates have many desirable properties, they have not been suitable for relatively large shapes or for small quantity production because of the expensive molds and heavy presses required by high-pressure laminating techniques. These limitations have now been overcome by the development of a technique for molding melamine-glass mat laminates at low pressures in the range from 150 to 200 psi.

This development is the result of a project sponsored by the Bureau of Ships and carried out by Auburn Button Works.

The low-pressure technique is suitable for complex shapes as well as flat sheets. It is outlined at the top of this page in conjunction with photographs of two molded shapes: a helmet and a clarinet case half. Since the melamine resins proved incompatible with the standard preforming techniques used for quantity production of polyester-glass parts, the parts shown were made by tailored mat lay-up.

Properties of low-pressure-laminated melamine-glass mat sheet are given in the table. These properties are compared with the requirements of the MIL-P-17721 specification for high-pressure-laminated melamine-glass mat sheet (Type GMM).

Properties

As the data indicate, the low-pressure laminates do not quite meet specification requirements for impact strength or flexural strength, but are well within the limits for water absorption. They meet all electrical requirements except that for arc resistance.

Other properties determined but not shown in the table include flexural modulus of elasticity and flammability. Average flexural modulus for ⅛-in. sheet in the "A" condition is 1.95 x 10^6 psi in the lengthwise direction and 1.62 x 10^6 psi crosswise. A ½-in. specimen subjected to a flame test (MIL-P-14) was charred and blistered after 10-min exposure but it did not ignite.

All properties were determined from specimens cut from 12-in.-square panels ⅛ or ½ in. thick. The materials and the impregnating and drying procedures used for the test panels were the same as for the pictured shapes. The ⅛-in. laminates required 7 or 8 plies and the ½-in. laminates 28 to 32 plies. Molding pressure was 200 psi and temperature was 300 F. Molding time was 15 min for the ⅛-in. laminates and 45 min for the ½-in. laminates.

Specimens cut from a molded clarinet case half, in both the lengthwise and crosswise directions, showed an average flexural strength of 23,600 psi. This value compares favorably with the data in the table obtained from laminated sheet specimens.

Effects of Variables

The low-pressure laminating technique described here is the outgrowth of an extensive study of the effects of several variables on the properties of melamine-glass laminates. These variables include use of filler, types of filler, resin-filler ratio and resin-glass ratio. Results of these investigations show that:

1. Flexural strength and water absorption properties of filled laminates, in most cases, are superior to those of unfilled laminates.

2. Solka Floc 100 Mesh (alpha cellulose) is a more effective filler than Asbestine 5x (magnesium silicate), Snowflake White (calcium carbonate) and Celite 110 (diatomaceous silica). Although it is an organic material, Globar tests indicate it does not significantly affect burning rate. China clay (aluminum silicate) is nearly as effective as alpha cellulose and produces a somewhat improved surface finish.

3. Alpha cellulose filler contents higher than that given here tend to result in high water absorption.

4. Glass content can be as low as 30% without sacrifice of physical properties. Laminates containing as much as 50% glass have higher flexural strength but are unsatisfactory because of porosity and poor surface finish.

Conventional melamine resins were selected for the formulation, since discussions with melamine resin suppliers indicated that there were no new resins available which offered greater promise for low-pressure laminating. Guanidine carbonate was added to induce resin flow at lower volatile contents.

The molding pressure of 150-200 psi was selected on the basis of experience in matched metal die molding of polyester-glass. For complex shapes, it appears to be about the minimum pressure necessary to force resin through the mold cut-offs and to insure that air is completely eliminated from the mold. (It also seems to be the minimum pressure necessary to develop optimum physical properties where mat or chopped glass preforms are used, although the melamine resins proved to be incompatible with these techniques.) However, reduction of molding pressure to 125 psi did not affect physical properties of water absorption of melamine-glass laminated sheet.

Low pressure molding should eventually broaden the applications for melamine-glass laminates, which offer excellent color stability, alkali and chemical resistance, arc resistance, heat resistance, surface hardness and abrasion resistance. Melamine-glass laminates also have superior resistance to ignition and burning compared with polyester- or phenolic-glass laminates—a property of particular interest in Naval applications.

Acknowledgment

The authors desire to express their appreciation to:

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Auburn Button Works, who carried out the work under Bureau of Ships Contract NObs-55195.

J. B. Alfers and L. E. Sieffert of the Bureau of Ships for their constructive comments.

American Cyanamid Co. and Monsanto Chemical Co. who served in a consulting capacity at the beginning of the investigation.

LOW-PRESSURE MELAMINE-GLASS MAT LAMINATES COMPARED WITH MIL-P-17721

Property	Condition of Laminate[b]	1/8-in. Laminates			1/8-in. Laminates		
		Avg (low-press)	Range (low-press)	Spec[a] (high-press)	Avg (low-press)	Range (low-press)	Spec[a] (high-press)
Dielectric Breakdown (parallel to laminations, step by step), KV	A	52, 60[c,d]	50[d]–55	45 min	49, 50[c,d]	47–50	35 min
	D-48/50	13.5, 20.0[c]	10.0–18.0	5.0 min	9.0, 17.0[c]	9.0–9.0	5.0 min
Edgewise Impact Strength (cut lengthwise and crosswise), ft-lb/in.	E-48/50	6.9	6.1–8.4	5.0 min	3.9	3.7–4.2	5.0 min
Flatwise Flexural Strength (cut lengthwise and crosswise), 10^3 psi	A	22.5	21.0–24.0	23.0 min	15.6	13.7–16.9	21.0 min
Bond Strength, lb	A	—	—	—[e]	1610	1520–1710	1200 min
	D-48/50	—	—	—[e]	1320	1055–1475	1075 min
Water Absorption, % in 24 hr	E-1/105 and D-24/23	0.7	0.3–1.0	2.8 max	0.2	0.2–0.3	2.0 max
Dielectric Constant at 1 mc	D-24/23	7.5	7.4–7.6	8.0 max	—	—	—[e]
Dissipation Factor at 1 mc	D-24/23	0.03	0.03–0.03	0.08 max	—	—	—[e]
Volume Resistivity, 10^3 megohm—cm	A	1070	643–1981	—[e]	—	—	—[e]
Surface Resistance, 10^3 megohms	A	3000	1240–5660	—[e]	—	—	—[e]
Arc Resistance, sec	D-48/50	171	135–185	180 min	183	182–185	180 min

NOTES: [a] *MIL-P-17721.*
[b] *Conditioning: A = as received.*
[c] *Short time test.*
[d] *Flashover occurred but no failure.*
[e] *Not required.*
D-48/50 = 48 hr in distilled water at 50 C.
E-48/50 = 48 hr at 50 C.
E-1/105 = 1 hr at 105 C.
D-24/23 = 24 hr in water at 23 C.

Quality Control

from Raw Material to Final Part

means

1. Fewer rejects
2. A better product

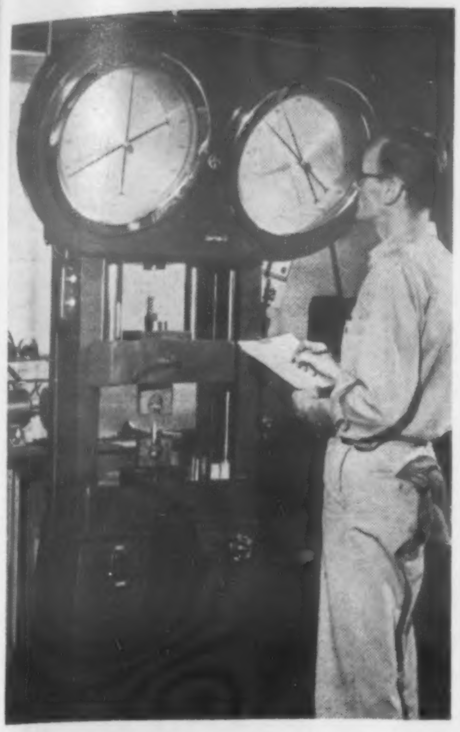
by Walter Wotus,
Aero Supply Mfg. Co.
Quality Control Supervisor,

■ A QUALITY CONTROL program means a better product. As a maker of aircraft hardware that must continually meet rigid United States Air Force specifications, Aero Supply has an overall quality control program that extends from original delivery of coil stock to final delivery of finished bolts. In essence it is based on six different kinds of inspection: laboratory, first piece, process, patrol, gateway and final. These inspections are designed both to cut down the final rejection rate and equally important to pin-point defects right at their moment of origin.

Aero's extensive quality control system has definitely decreased the rejection rate. In 1952, the first full year quality control was instituted, bolt rejections amounted to 3.1%; in 1953, they were down to 2.4%; while for the first 8 months of 1954, the rate was down again—to 1.7%.

1 Raw coil stock for bolts when received is first weighed. All stock must be accompanied by material certification, which is periodically checked by independent laboratories. Here—at the beginning—coil receives heat and control numbers that will stay with it throughout manufacture.

2 Magnetic particle inspection is used to check raw material for stress, heat treat, grinding cracks, or flaws. Where tested samples show more than average fracture, the entire lot is given 100% inspection.



3 Property tests are made on two control-labeled specimens from each coil. These include tensile, hardness, decarburization, shearing and bending tests. Partially manufactured bolts return periodically to laboratory during various production steps, i.e., after heat treating and electroplating.

4 First piece inspection by patrol inspector in Bolt Heading Dept. All characteristics must be inspected to specifications before actual production can begin.

5 Process and control inspections. Operator inspects machine output and records results in Process Control Chart every fifteen minutes. Patrol inspector records on the average every half hour. Attribute chart is maintained at each machine and is analyzed by Quality Control Dept. for machine performance and capability.

6 Rockwell test and re-test. Before electroplating, parts are Rockwell-checked again for hardness to make sure they have not become mixed in transit.

7 Special electroplating inspections, again by both operator and patrol inspector. Every bolt lot is sample-inspected for plating thickness by the drop test method and recorded on charts. Thread form and PD is checked with ring and drop thread gages.

8 Final inspection. Although bolt lots have already undergone more than a dozen checks, there is rigid final inspection of bolt samples. Here, inspector using sampling tables, checks effects of plating buildup on body size and threads.

How to Weld Some

Wrought High Alloys

Although readily joined by the common welding processes, each of these alloy materials has particular characteristics that must be taken into account in planning joint design and welding procedures.

by R. P. Culbertson, *Haynes Stellite Co.*

■ THE INCREASING USE of high alloys as materials of construction has created a demand for more information on their fabricating characteristics. Much development work has been centered on the joining of these alloys capable of resisting corrosion, high temperatures plus oxidation, stresses, and mechanical shocks. It is the procedures for joining, and the properties to be expected of weld joints in some of these alloys, that will be discussed in detail here. The accompanying table shows the composition of these representative alloys and their average mechanical properties.

Nickel-molybdenum

This is a corrosion-resistant alloy designed to handle boiling hydrochloric acid, wet hydrogen chloride, sulfuric acid, and other corrosives. It is readily weldable in the horizontal and flat positions, and may be welded in the vertical position if sufficient skill is acquired. However, welding in the vertical position is not recommended except in cases of emergency. The alloy is extremely fluid during deposition, and careful handling is required to avoid undercutting and poor bead contour. Welding techniques in general are similar to those used in the welding of stainless steel. However, the following precautions should be observed:

1. Use stringer beads at all times (no weaving).
2. Do not preheat or post heat.
3. Keep weldment as cool as possible. Quench with rag and water wherever possible.
4. Use striking tabs where possible.

By observing these rules and using proper joint design, few difficulties will be experienced. A study of the mechanical properties of the alloy before designing the weldment will be helpful too. Elongation drops from 40% at 800 F to 9% at 1350 F and then increases to approximately 30% at 1800 F. The reduction of area follows this same trend. From these data, it may be seen that it is important to pass through the temperature range of 1800 to 1100 F as rapidly as possible during cooling, and to design and position the welds in a manner that will subject them to the least restraint.

Cracking is rarely experienced in the weld deposit. When cracking does occur, it usually appears in the base material. Such cracking is very fine, approximately 1/8 in. long, and usually transverse to the weld. In cases of extreme restraint, where the welded part might be a spud in a tank shell, for example, the cracking will occur parallel to the weld. However, when the characteristics of this alloy are understood, little or no difficulty is experienced in its welding.

CHEMICAL COMPOSITION AND AVERAGE MECHANICAL PROPERTIES

	Nickel-Molybdenum	Nickel-Molybdenum-Chromium	Cobalt-Nickel-Tungsten	Alloy N-155
Iron	4.0–7.0	4.5–7.0	3.00 max	Balance
Chromium	1.00 max	15.5–17.5	19.0–21.0	20.0–22.5
Nickel	Balance	Balance	9.0–11.0	19.0–21.0
Carbon	0.05 max	0.15 max	0.15 max	—
Tungsten	—	3.75–5.25	14.0–16.0	2.0–3.0
Silicon	1.00 max	1.00 max	1.00 max	—
Manganese	—	1.00 max	1.0–2.0	—
Cobalt	—	—	Balance	18.5–21.0
Columbium	—	—	—	0.75–1.25*
Molybdenum	26–30	16–18	—	2.5–3.5
Ultimate Strength (Annealed), psi	135,000	130,000	155,000	111,500
Yield Strength, psi 0.2% offset	60,000	54,000	70,000	71,000
Elongation, %	45	35	55	44

*Columbium-Tantalum.

Nickel-molybdenum alloy *heat exchanger pipes are joined with 180-deg return bends by metallic-arc welding. U-shaped fins which are also made of the alloy are welded to pipes by machine.*

Inert-Gas-Shielded Arc Welding—All recommendations discussed up until now should be followed when the inert-gas-shielded arc process is used for joining. In general, the conditions observed while welding the high-alloy materials by this method were similar to those which occur during the welding of stainless and high-alloy steels.

The preferred power supply is direct current, straight polarity with electrode at negative potential. A tungsten electrode of the smallest diameter to carry this current is recommended, and the gas may be either pure argon, argon with one per cent oxygen, or pure helium. The gas flow of argon should be about 30 cu ft per sec. Electrodes are normally operated at maximum current density in order to obtain best arc stability. It has been found, however, that use of 1/16-in. dia electrodes under these conditions creates excessive electrode contamination and results in excessive tungsten deposits in the weld puddle. This problem is materially reduced by using a 3/32-in. dia electrode ground to a long needle-like point.

Precautions should be taken to prevent drafts from dispersing the gaseous shield. If the shield is dispersed, oxidation and subsequent porosity may result. Excess nitrogen will cause porosity in inert-gas-shielded arc welds of this alloy. This condition can be minimized by shielding reverse side of the weld. Any aspiration of air into the weld deposit can be eliminated by using proper joint design and adequate weld shielding. It is also practical to use some form of back-up paste to assure root protection as well as to secure good under-bead contour.

Submerged Melt Welding—Nickel-molybdenum alloys may be welded successfully by the submerged melt process. For best welding conditions, a power supply of direct current, reverse polarity (electrode positive) should be used.

A granular welding composition should be selected to give maximum protection to the welds and to keep silicon and manganese pick-up at a minimum. These impurities will impair the corrosion-resistant properties of this alloy. The heat-affected zone will be wider with the use of this process, and the cracking tendency may be increased by the higher heat input. However, this condition can be offset by careful joint design.

It is apparent from the table that ductility of submerged melt welds is rather poor and subsequent transverse bead tests were very unsuccessful because of weld cracking with bend angles of 60 to 90 deg.

MECHANICAL PROPERTIES OF NICKEL-MOLYBDENUM ALLOY IN AS-WELDED CONDITION

Weld Method	Thick, in.	Ult Str, psi	Yld Str, 0.2% offset	Elong, % in 2 in.	Hardness (Average)		
					Plate	By-Weld	In-Weld
Metallic Arc	⅛	122,000	68,000	16	62 (a)	61 (a)	53 (a)
Heliarc	⅛	117,000	59,000	30	57 (a)	59 (a)	55 (a)
Submerged Melt	¼	114,000	66,000	23	—	—	—
Metallic Arc	¼	123,000	53,000	42	91 (b)	92 (b)	93 (b)
Heliarc	¼	115,000	60,000	30	92 (b)	93 (b)	95 (b)
Metallic Arc	⅜	121,000	60,000	37	97 (b)	97 (b)	93 (b)
Heliarc	⅜	125,000	49,000	42	92 (b)	94 (b)	90 (b)

(a) *Rockwell A.*
(b) *Rockwell B.*

Joint Design and Preparation

High alloys of the types covered here do not have the fluidity of steel during a welding operation. Therefore, when "V" or "U" or "J" grooves are used, it is necessary to provide a slightly larger clearance than would be needed for steel. This larger clearance allows for cleaning and better accessibility during welding. See accompanying drawing for comparison of joint designs for high alloys to standard joint types.

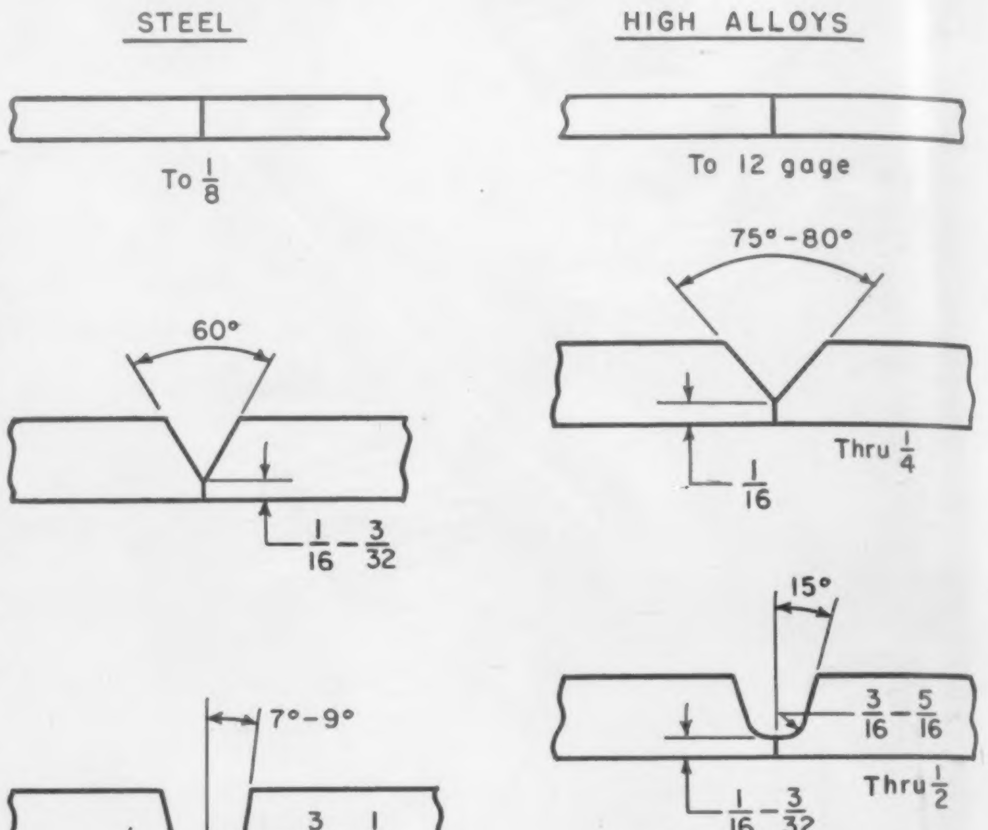
Use of back-up rings should be avoided when designing containers or pipe lines to be used for carrying corrosive media. Crevices cannot be avoided in this type of design and these may become points of cell-type and stress corrosion, notch effect, and root cracking.

In general, material 12-gage and heavier should be beveled and welded from both sides. When joining material of dissimilar thicknesses, the heavier section should always be beveled for ease of welding. For material 12-gage and thinner, the welding may be accomplished from one side by using proper edge spacing to allow full penetration.

Care should be exercised to eliminate non-uniform penetration. This condition can leave undesirable crevices and voids in the underside of the joint which, as noted before, contribute to areas of accelerated corrosion. Non-uniform penetration in material used for high-temperature applications creates stress risers for focal points of mechanical failure.

Welding from both sides is recommended wherever possible. When this is not practical, joint spacing should be increased and a copper back-up bar used. Currents slightly higher than normal are then used to obtain complete penetration.

Beveling by machine is the surest way to obtain correct fits. A planer, shaper, grinder, or other machine tool can do this job accurately. When sheared sheet or plate is used, the sheared edges should be ground back approximately 1/16 in. to remove any stressed material before the edge is prepared for welding. In *all* instances, the edges should be squared, ***aligned properly***, and tacked before welding. The



All dimensions are in inches

alignment and edge preparation are particularly important in this class of alloys. Any misalignment causes variation in bead contour, gap width, and stresses in the weld area. These factors contribute to cracking in the weld joint. Since initial metal cost is fairly high, the slight additional cost of careful preparation to assure good welds is well justified. Thermal cutting and beveling of plates can be done, but these are not recommended.

In general, the "V" joint preparation is used for butt welds in plate thicknesses up to ¼ in. and a "U" joint for greater thicknesses. The "V" or "U" joint is used where the welded material will be exposed to high stress. When these types of weld construction are used, the stress will act axially. The lap or tee joint may be used for conditions of lower stress.

The "U" joint preparation is preferred for material greater than ¼ in. thickness. While the cost of preparation may be increased by this type of joint, the amount of welding materials and man hours needed for welding will be much less than if a "V" joint is used. Also, the amount of residual stress will be lower, since less weld material is required and less transverse shrinkage is incurred.

It is generally desirable to provide a grooved back-up bar of some sort. When using a back-up or chill bar, a groove of the proper contour is usually provided to permit good penetration and bead contour. For arc welding, the grooves should be of a minimum depth, usually from 3/32 in. to 1/16 in., and approximately 3/16 in. wide. The corners of the groove should be rounded. Square corners cause poor bead contour, flux pockets, and non-uniform heat transfer.

Nickel-molybdenum-chromium

This is a corrosion-resistant alloy designed to withstand strong oxidizing media such at nitric acid and wet chlorine. In general, it may be welded and fabricated using the same procedures and techniques as applied to nickel-molybdenum alloy. This alloy has slightly lower tensile strength, yield strength and elongation. However, nickel-molybdenum-chromium alloy is not subject to as much loss of ductility in the range of 900 F to 1800 F as the nickel-molybdenum alloy, and therefore, is not as prone to hot-short cracking. This characteristic allows more latitude in welding and fabricating of this alloy; however, welding procedures described under nickel-molybdenum alloy should be followed for ease of welding. When cracking does occur because of severe restraint, it usually follows the same pattern as described for nickel-molybdenum alloy.

For metallic-arc joining of this material, a direct current reverse polarity power source is used. To obtain ultimate mechanical and corrosion properties, lime-coated electrodes should be used. Although this material is readily welded with lime-titania type electrodes, it is generally accepted by the field that better metallurgical properties and better corrosion resistance of welds are obtained by use of lime-coated electrodes.

Inert-Gas-Shielded Arc Welding — Nickel-molybdenum-chromium alloy is not as prone to porosity when joined by this process as is the nickel-molybdenum alloy and, in general, exhibits slightly better welding characteristics. This property is attributed to the added chromium content of this alloy. The same welding practice should be adhered to as for nickel-molybdenum alloy.

A comparison of properties in the tables shows that the nickel-molybdenum-chromium alloy exhibits slightly lower tensile strength, yield strength and elongation.

Inert-gas-shielded arc welding has been generally accepted as the best method of joining materials to be used in corrosion applications. Welds produced by this method are of slightly higher quality than those obtained with the metallic-arc method. Possible slag inclusions, pick-up of stray elements from the coating, excessive burn-out of metallic elements in the rod, etc., are not as pronounced. However, the time element may be the deciding factor, in which case, the metallic-arc method would, of necessity, be used.

MECHANICAL PROPERTIES OF NICKEL-MOLYBDENUM-CHROMIUM-ALLOY AS-WELDED CONDITION

Weld Method	Thick, in.	Ult Str, psi	Yd Str, 0.2% offset	Elong, % in 2 in.	Hardness (Average)		
					Plate	By-Weld	In-Weld
Metallic Arc	⅛	117,000	68,300	20	59 (a)	60 (a)	60 (a)
Heliarc	⅛	121,000	66,000	25	60 (a)	57 (a)	60 (a)
Metallic Arc	¼	129,000	67,000	28	87 (b)	90 (b)	91 (b)
Heliarc	¼	113,000	59,000	32	97 (b)	97 (b)	96 (b)
Unionmelt	¼	105,000	68,000	13	—	—	—
Metallic Arc	⅜	118,000	66,000	22	52 (a)	51 (a)	54 (a)
Heliarc	⅜	117,000	64,000	25	54 (a)	56 (a)	56 (a)
Unionmelt	½	102,000	64,000	13	—	—	—

(a) *Rockwell A.*
(b) *Rockwell B.*

Nickel - molybdenum - chromium alloy *used to line entire inside surface of this petrochemical tower. First, alloy sheet was joined to steel shell by metallic-arc welding. Then, narrow strips of alloy were placed over arc welds and joined to lining by inert-gas, shielded-arc welding.*

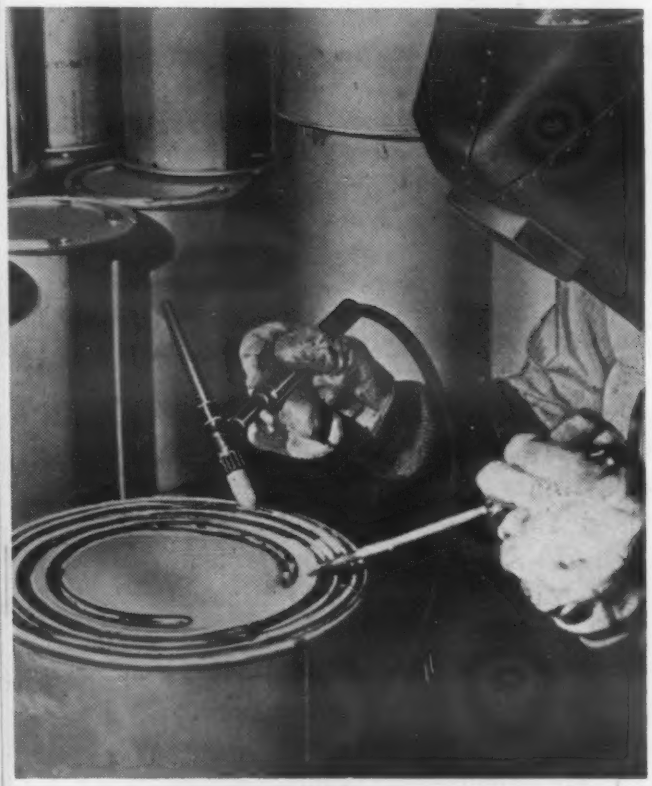
Submerged Melt Welding — Nickel - molybdenum - chromium alloy may be welded by the submerged melt welding process under the same conditions used for welding nickel-molybdenum alloy. The comparison shown in the two tables indicates that a lower level of mechanical properties exists for the nickel-molybdenum-chromium alloy, however. Submerged melt welds in the nickel-molybdenum-chromium alloy exhibit the same poor transverse bend properties as described in the previous discussion of nickel-molybdenum alloy.

N-155 alloy

This material is used in parts exposed to high temperature and oxidation. Some typical uses incones, cabin hot-air heat exclude gas turbine engine tail changers, after-burner sections, etc. The alloy is subject to the same welding and fabricating procedures as outlined in the foregoing sections, although the difficulties encountered are of a different nature. This material has a slightly lower tensile strength, yield strength, and elongation than nickel-molybde-

MECHANICAL PROPERTIES OF N-155 ALLOY IN AS-WELDED CONDITION

Weld Method	Thick, in.	Ult Str, psi	Yld Str, 0.2% offset	Elong, % in 2 in.	Hardness (Rockwell B)	
					Weld	Adj to Weld
Heliarc	1/8	108,000	61,000	24	91	94–89
Metallic Arc	1/8	116,000	61,000	27	—	—
Heliarc	1/4	115,000	66,000	23	90	91–91
Heliarc	3/8	109,000	56,000	19	90	93–94
Metallic Arc	3/8	115,000	64,000	26	92	90–90



N-155 alloy sheet sections *in aircraft cabin heater are joined by inert-gas-shielded arc welding. Unit burns aviation gas and generates 200,000 Btu per hr.*

num and nickel-molybdenum-chromium alloys.

This alloy does not have as critical a hot-short range as the other alloys thus far discussed, but retains nearly a straight-line function to about 1700 F. The ductility drops off sharply at this point. This phenomenon appears to correlate with the sensitivity of this alloy to microfissuring when the proper welding procedures are not pursued. Since the ductility is so markedly reduced at 1700 F, it is assumed that microcracking takes place directly after the liquid to solid transformation during welding. When welding this alloy (with any process), therefore, it is extremely important to pass through this critical range as quickly as possible by:

1. Using stringer beads
2. Quench welding (use wet rags or water spray)
3. Keeping interpass temperature at room temperature
4. Keep base material at room temperature

The nature of cracking or microfissuring encountered in welding N-155 is very similar to that encountered in chromium-nickel stainless weld metal. Cracking is always more prevalent in the fully austenitic weld metals than in the partially ferritic weld metals.

The influence of electrode coating is mainly one of degree. That is, if other conditions favor cracking, the type of coating may increase or decrease the amount of cracking. For example, an alloy which is notably crack-sensitive when deposited by titania type of electrode, may become free from cracks by eliminating the titania from the coating. This conclusion applies to N-155 alloy and has been proven by experimentation using the standard circular groove type specimen, to indicate weld bead cracking. Electrodes furnished for this material are, therefore, lime-coated unless otherwise specified.

It has often been conjectured that columbium attributes crack sensitivity to a material; however, this has neither been proven nor disproven for N-155 alloy.

Inert-Gas-Shielded Arc Welding—N-155 is welded readily by the inert-gas-shielded arc method using the previously outlined procedures and practices. A minimum of heat input should be used, followed by rapid cooling of the weld deposits.

Submerged Melt Welding—This material does not lend itself readily to submerged melt welding of heavy plate, because of the microfissuring characteristic. In general, submerged melt welds in heavy plate produce high heat input to the base material and slow cooling. Welds may be made satisfactorily in the thinner gages, with this process.

Cobalt-chromium-tungsten-nickel

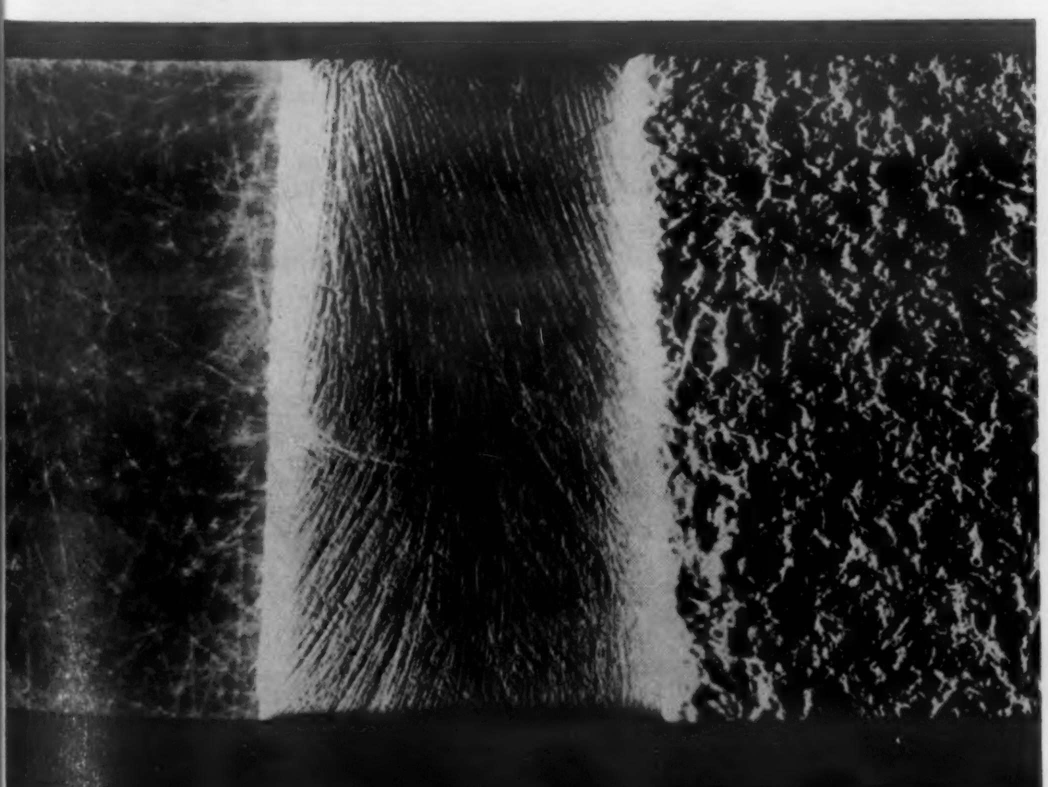
This material is a high-temperature oxidation-resistant alloy that has high strength and oxidation resistance at 1800 F. It possesses higher mechanical properties, such as tensile strength, yield strength and elongation than those shown by the other alloys discussed. This material is readily weldable by the several processes discussed here and by utilizing the same procedures, joint design, etc., no difficulties should be encountered.

The elongation of this alloy drops off sharply at 900 F and at 1300 F where it is approximately 15% and rises to 20% at about 1900 F. It is subject to hot-short cracking, much the same as nickel-molybdenum alloy, and the same considerations used for the nickel-molybdenum alloy should be applied to it to secure good welds.

This article was adapted from a paper presented at the American Welding Society Fall Meeting, November 1954.

Materials at Work

New and old materials in unusual applications

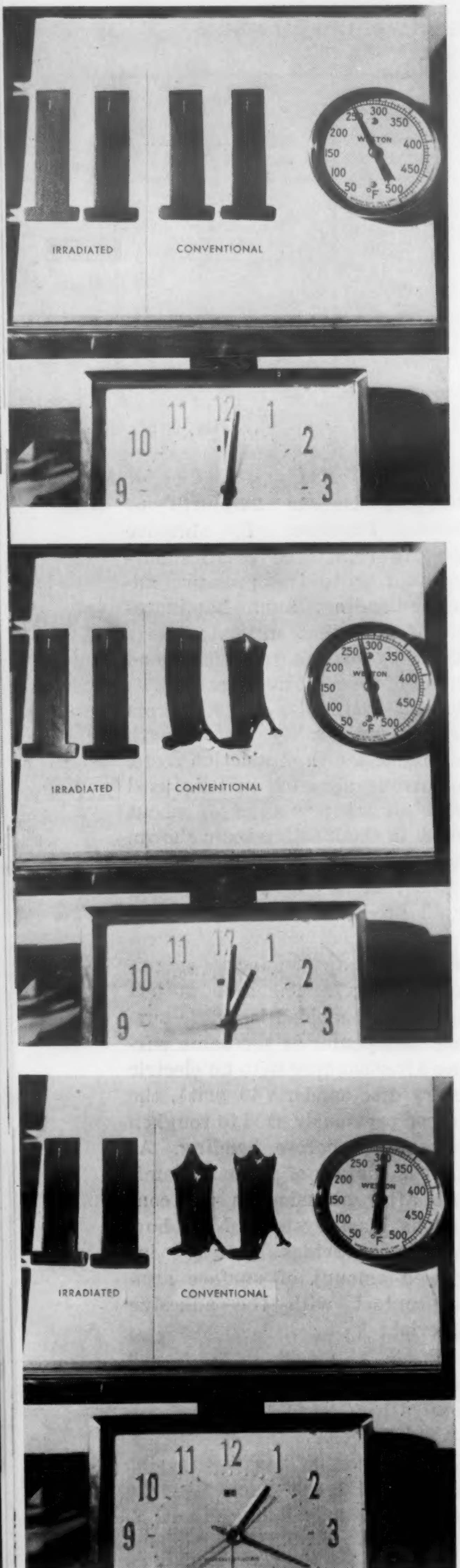


Blasting Boosts Strength of Bonded Plastics By abrasive blasting reinforced plastics surfaces prior to low pressure adhesive-bonding, Lunn Laminates Inc. found that ultimate shear strengths of the resulting bond were improved an average of 22%. Benefits were also derived from greater uniformity of strength and reduction in production costs. A ferrous abrasive grit is used with air at pressures of about 60 psi in the blasting room shown. Parts move through the room on a continuous belt, permitting rapid production.

Shown at bottom are three comparative plastics surfaces (magnification 2.4x). The area at left is a typical molded laminate surface. At center is the same surface after sanding with an electric rotary disc sander (40 grit), the method previously used to roughen the surface before bonding. At right is surface of the same laminate after abrasion in the continuous blast system. Note how blasting provides greatly increased amount of surface area for contact with the adhesive material.

New Developments in

Irradiated Polyethylene



■ LAST SUMMER, General Electric Co. began to market developmental quantities of an irradiated polyethylene tape known as Irrathene 101.

In September, M & M published an article (pp 91-5) describing the new material and the background of its development.

Since then, interest in irradiated polyethylene has mounted rapidly, with the result that the new material is now available in a variety of standard forms and can also be readily obtained in custom forms of limited size for experimental purposes. Here are the most important developments:

General Electric Co. now offers developmental quantities of a more heat-stable variety of irradiated polyethylene tape. The new tape, called Irrathene 201, is suitable for continuous use in air at temperatures up to 250 F, whereas the earlier tape, Irrathene 101, was subject to deterioration in air at temperatures above 220 F. The new tape is expected to be particularly suitable for turn insulation on electrical circuit breakers.

Anchor Plastics Co., offers polyethylene tubing, rods and other extruded shapes, as well as custom-fabricated items made from polyethylene extrusions, that have been subjected to various specified irradiation dosages.

American Agile Corp., under the tradename Agilene-HT, offers standard laboratory ware items, such as beakers, funnels, and graduated cylinders, made of irradiated polyethylene. This company also offers irradiated polyethylene sheet, rods, tubing, pipe, blocks and custom-fabricated items.

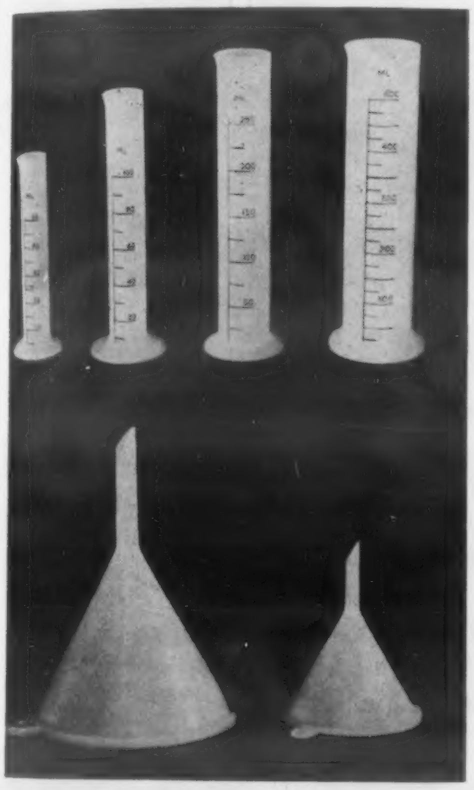
Essentially, irradiation converts polyethylene from a thermoplastic to an infusible material. Irradiated polyethylene exhibits no stress-cracking. Although its solvent resistance is only slightly improved at ordinary temperatures, it is much improved at elevated temperatures. There seems to be some evidence that elevated temperature dielectric strength is also improved. Irradiated polyethylene becomes elastometric at elevated temperatures. Irradiation does not significantly improve room temperature strength or toughness, and the advantages offered by irradi-

The difference *between irradiated and non-irradiated polyethylene extrusions is illustrated by this sequence photographed by Anchor Plastics. The 0.050-in. thick die-cut pieces (top) were inspected after 1 hr at 275 F (middle) and again after 20 min at 300 F (bottom). Dosage for irradiated pieces was 32 x 10^6 rep (Roentgen equivalent physical). Similarly, a conventional polyethylene beaker is shown below in its original form and after 3, 6, 8 and 10 min at 300 F. By way of contrast, the Agilene-HT beaker at the extreme right is shown after 1 hr at 300 F.*

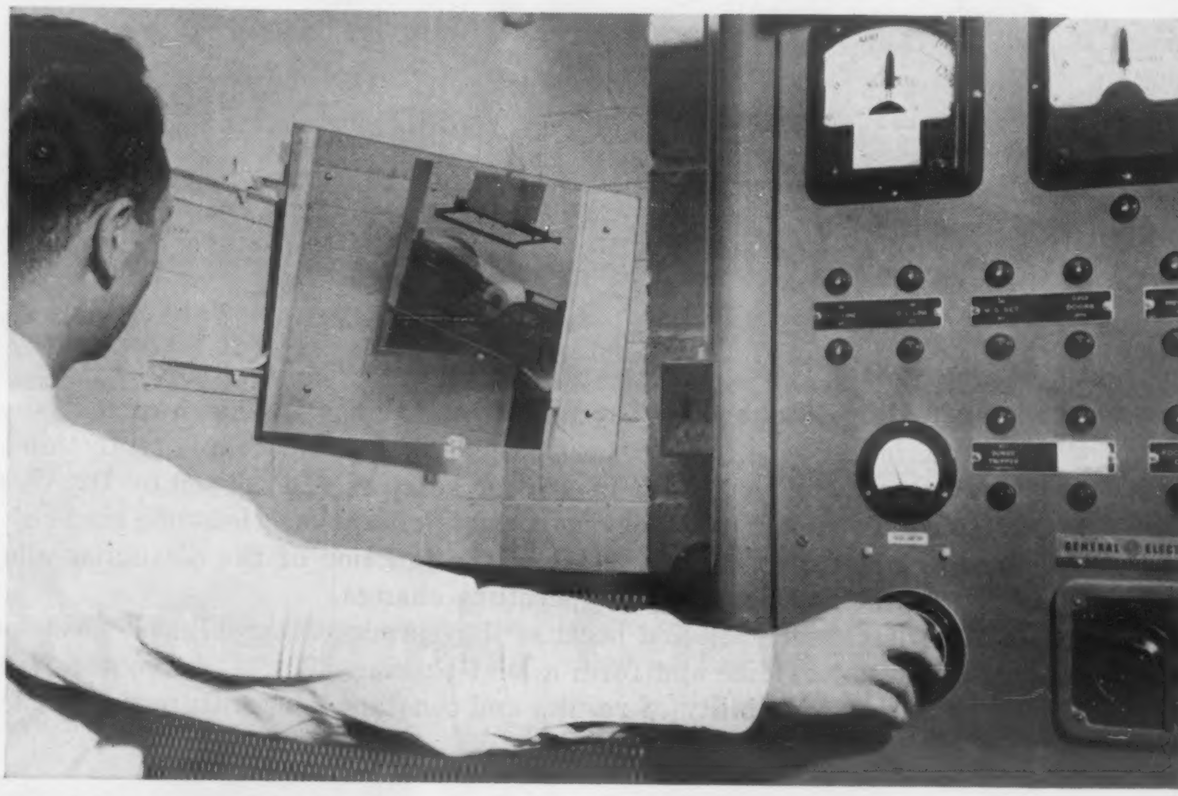
ated polyethylene are pretty much confined to elevated temperature applications. Whereas ordinary polyethylene melts at about 230 F, irradiated polyethylene can be used continuously at this temperature and it maintains form stability under no load at temperatures as high as 350 F. However, injection-molded parts that have been irradiated tend to warp due to relief of molding stresses just as do non-irradiated parts.

All products currently available are being irradiated by electron bombardment, not by nuclear processes. General Electric's tape is irradiated by one of that company's standard million-volt resonant transformer-type X-ray machines. Anchor Plastics' extrusions and American Agile's products are being irradiated by a Van De Graaff electrostatic accelerator, in cooperation with High Voltage Engineering Corp.

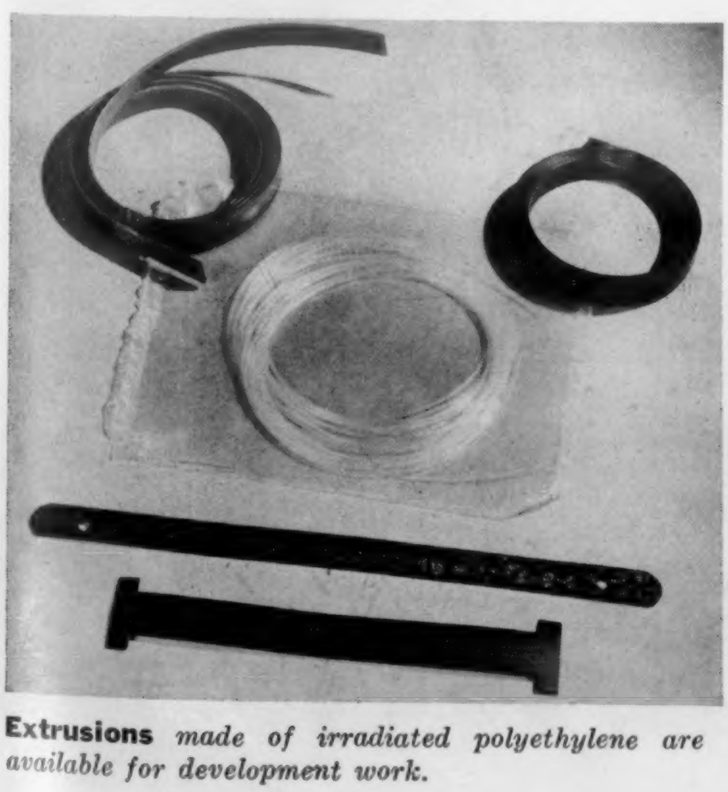
Applications Grow



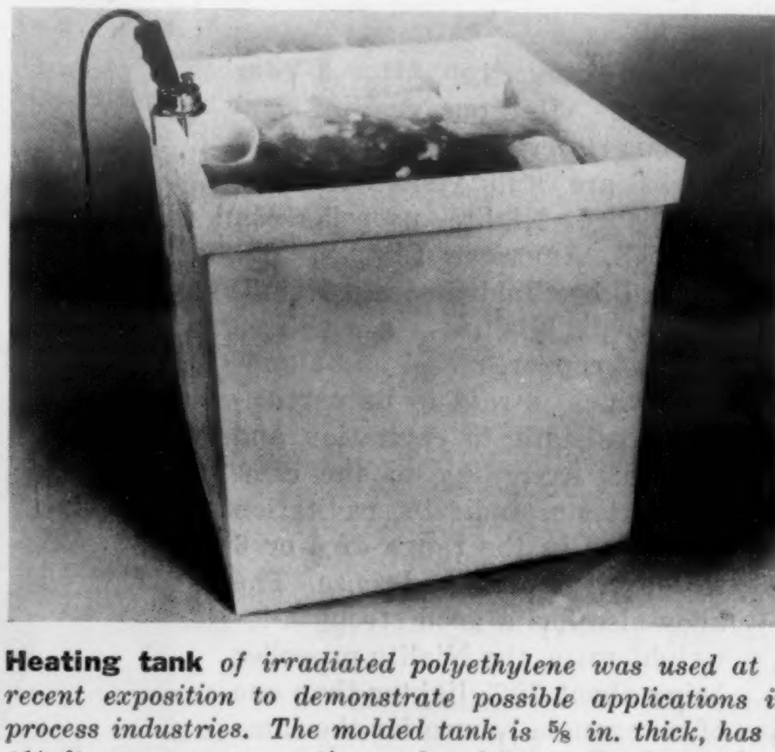
Laboratory ware *made of irradiated polyethylene.*



Electrical insulating tape *suitable for continuous exposure in air at temperatures up to 250 F is available in developmental quantities.*



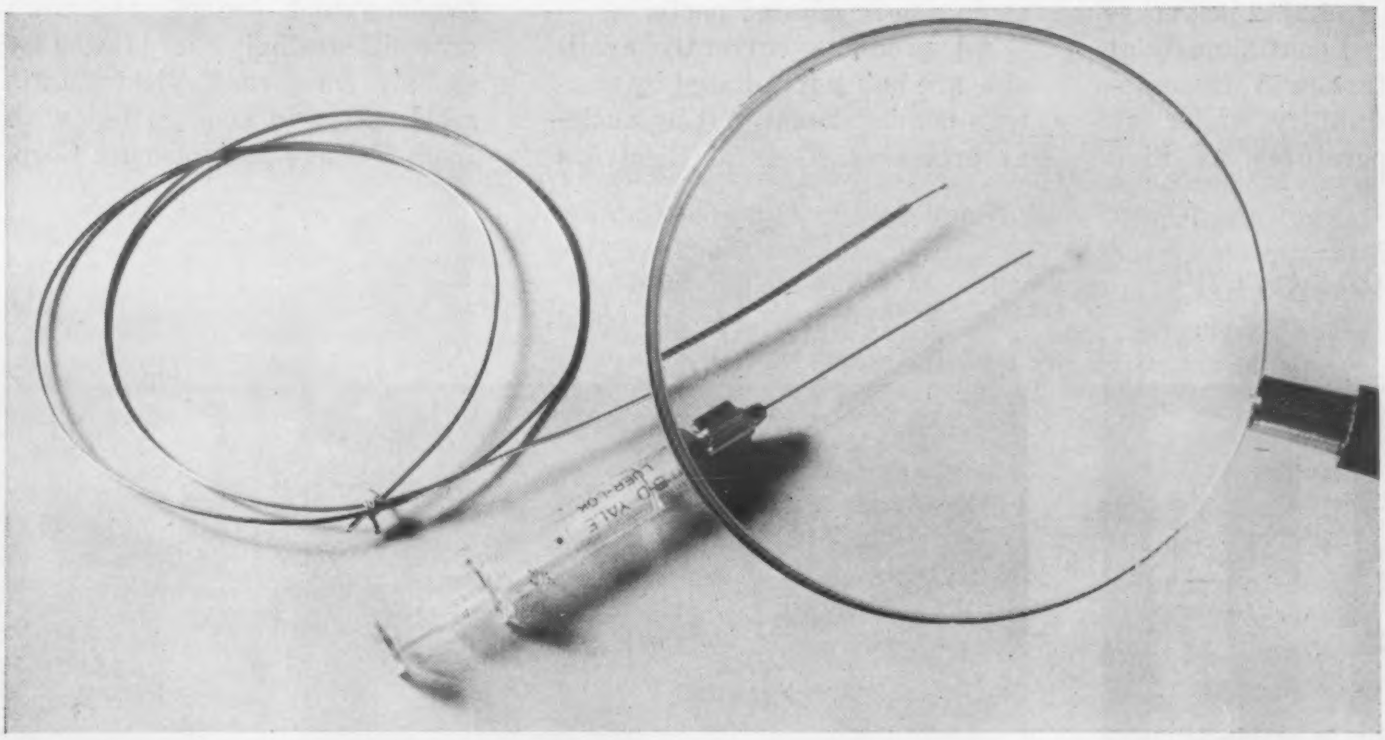
Extrusions *made of irradiated polyethylene are available for development work.*



Heating tank *of irradiated polyethylene was used at a recent exposition to demonstrate possible applications in process industries. The molded tank is ⅝ in. thick, has a 1½-ft square cross section and weighs 33 lb. It stood up successfully under a prolonged load of boiling water (heated by immersion heater), as did the immersed Agilene-HT beakers.*

Materials at Work

New and old materials in unusual applications



Nickel Alloys Make Tiny Thermocouple "Snake" Shown compared with a hypodermic needle is a section of a 20-ft long thermocouple and thermocouple protection tube designed to measure temperatures up to 1250 F in nuclear reactors. Developed by Dr. W. G. Rauch at the Argonne National Laboratory, the device consists of a protection tube made of Inconel and a constantan (copper-nickel alloy) wire. Heat at the junction of the dissimilar alloys creates a flow of electricity which varies with temperature change.

The alloys were selected because they produced the highest electromotive force and the Inconel will not oxidize and form a heat barrier. The thermocouple "snakes" are said to provide accurate reproducibility of results and constant temperature readings during repeated heating and cooling cycles.

Copper Alloy Prop After 1-Year Service After one year of continuous service, buffing swirl marks are still visible on this five-bladed Nialite propeller on the S.S. American Clipper. Developed by Baldwin-Lima-Hamilton Corp., Nialite is a zinc-free alloy of copper, nickel and aluminum which is said to be particularly resistant to cavitation and erosion. According to the company, tests indicate cavitation resistance in the range of 4 or 6 to 1 over manganese bronze. The alloy also has a good strength-to-weight ratio, the Nialite propeller being about 20% lighter than one of manganese bronze for the same ship.

Water solutions *of metallic salts can be easily sprayed on both metal and non-metal surfaces.*

Deposited coatings *withstand extreme heat and chemical attack. Here, inside of rocket tube is sprayed.*

New Solution Ceramic Coatings

..............can be sprayed................resist heat and corrosion

by Kenneth Rose, *Midwestern Editor, Materials & Methods*

■ NEW REFRACTORY OXIDE COATINGS applicable to a wide variety of surfaces have been developed at Armour Research Foundation. The films can be applied easily and without expensive equipment. The heat required is considerably below the vitrifying temperatures of most porcelain enamels.

What they are

The materials, called solution ceramics (patents applied for), are deposited as true water solutions rather than as suspensions of solids in water. The film is formed by spraying a solution of a metallic salt onto the surface to be coated, with the surface warmed sufficiently so that moisture is removed and the salt is reduced to the oxide. The oxide is tightly bonded to the surface, apparently by molecular attraction. The surface should be clean, but does not require any special preparation.

The oxides that have been given special attention are those of zirconium and chromium, which have good refractory properties. Oxides of titanium, cerium, and magnesium have been applied also. Zirconium oxide possesses good dielectric properties, especially at low temperatures. Some phosphates, silicates, fluosilicates, oxyhalides, and even metals have also been applied.

Spraying the solution onto the surface to be coated is done with a spray gun of conventional type. The base material is heated to a temperature determined by the kind of solution being applied to it. The spray gun is held about two feet or so from the surface when applying the solution. As the mist of solution is sprayed at the heated surface, the water evaporates from the droplets of solution, and solid particles impinge upon the surface. These decompose to the oxide of the metal that formed the metallic salt in solution.

The position of the spray gun is important to good bonding. If the gun is held too close, some steam collects on the work surface, again causing poor adhesion.

Decomposition to the oxide leaves the very small particles tightly adhering to the surface

of the base material. The temperature at which decomposition occurs, and therefore the temperature at which the base material must be heated during spraying, varies from about 400-450 F for decomposition of ammonium zirconyl carbonate to zirconia, to about 700 F for decomposition of chromium nitrate to chromium oxide.

Their properties

The coatings are porous, and composed of many extremely fine crystallites. X-ray diffraction studies show no fixed pattern of banding, indicating that the particles are smaller than the wave length of light. The films are usually of the order of one mil thick. They can be built up to about 10 mils if desired, but at greater thicknesses the film loses in adhesion. The coatings are not particularly hard, and can be scratched with a knife blade.

The particles will adhere to almost any surface, smooth or porous. In tests, the coating has been applied to such diverse materials as metals, sand molds, paper, and glass. The base material must be capable of withstanding the temperature required to decompose the salt to oxide, and this is in the 400-700 F range, as stated before. There is experimental evidence that this limitation is not fixed and absolute, for some films can be formed at room temperature from chilled solutions.

Coated materials can be moderately bent, twisted, or elongated without damage to the coating, but if sharply bent, the coating comes off as a powder.

The films protect against corrosion by solids or viscous liquids, particularly at elevated temperatures, and protect against atmospheric attack at high temperatures. In a test, molybdenum coated with a layer of chromium oxide 0.0005 in. thick showed a 90% lowering in the rate of initial attack in still air, but molybdic oxide formed under the ceramic film. Steel coated with zirconium oxide has withstood as much as 200 hr in the salt spray test, but rusted eventually. The films offered best protection against mechanical erosion by gases, and against atmospheric gases at high temperature.

Dielectric strength of the films seems to offer another field of application. Zirconia films on mild steel show a d.c. resistivity of more than one megohm per centimeter cube at room temperature. Conversely, chromium oxide films show a resistivity of less than one ohm per centimeter cube, though the solid material has good dielectric strength.

Thermal resistance of the ceramic coatings is notable. Steel plates coated with zirconia films have been heated to temperatures approaching the melting point of steel, then quickly immersed in cold water, without apparent damage to the coating. The same film will slow the cutting rate of the steel when a cutting torch is used. Thermal conductivity is low also. A zirconia film on aluminum permits the application of borosilicate glasses by flame spraying, and subsequent flame polishing of the glass. A one-mil film of chromium oxide was shown to be as effective as 20 mils of kyanite chill paste in regulating chill depth in cast iron.

The films can be modified without loss of adhesion. Waxes, resins, or silicones may be used to impregnate some of the films, and others can be modified chemically, as in the conversion of calcium oxide films to calcium carbonate.

Where to use them

Solution ceramic coatings are so new that applications have not as yet been developed on a commercial scale. Experiments have indicated many lines holding promise of commercial utilization, however, and development work is progressing.

As a refractory coating for sand molds and cores, the films will reduce or eliminate burn-in and assist in production of cleaner castings. Their possibilities in controlling chill depth have already been referred to. Their possible value as a coating for ladles, crucibles, stoppers and inserts is being considered also. Another use in the casting field may be the coating of die casting reservoirs and metal pumps to prevent the wetting and attack of the metals of construction.

Applications revolving about its electrical resistivity include its possible use as a high-temperature coating for resistor wire or tape, condensers, and thermocouples. As a refractory and protective coating for metal parts exposed to high temperatures, the ceramic films show promise. They have been applied experimentally to glass and ceramic tile and pottery, and may provide an efficient method for decorating such pieces with colorants, either to be fired later or used without firing. If the applied film is metallic in nature, an electrically conductive layer may be laid down on nonconductors.

The ease with which the films can be coated or impregnated is the basis for studies of its usefulness as a lithographic stone in printing. It has been found to take ink well.

As a base coat, the films may help in the production of vitrified enamel finishes. Experiments have shown that laying down a film of the new ceramic on ordinary hot-rolled steel permits adhesion of vitrified enamel, even when only one coat of the fired finish is applied over the sprayed film. One-coat enamels have been successful only when applied to special enameling steels, notably the titanium-bearing types.

Sound-deadening layers of rockwool under automobile hoods have been enclosed in asbestos paper to prevent strands of the rockwool from working loose. It has been found that spraying the asbestos paper with a ceramic film, and giving the whole a black finish, makes a more satisfactory job.

Silicones

Properties and Uses

MATERIALS & METHODS MANUAL No. 113

This is another in a series of comprehensive articles on engineering materials and their processing. Each is complete in itself. These special sections provide the reader with useful data on characteristics of materials or fabricated parts and on their processing and applications.

by Kenneth Rose, *Midwestern Editor, Materials & Methods*

In the last decade, a new group of materials has emerged from the laboratories to become part of our everyday lives. They are the silicon-base polymers, and they may be found in a multitude of industrial and consumer products ranging from aircraft gaskets to auto polishes. This manual describes the significant properties and the most important current applications of the "silicones", including—

- Silicone Fluids and Compounds
- Silicone Resins
- Silicone Rubbers

SILICONES—WAR BABY THAT GREW

The element carbon has always been unique in chemistry in that it has been possible to build from it an infinite number of compounds by substitution and joining reactions. The chemistry of the complex carbon compounds is called *organic chemistry.* Recent developments now make it possible to duplicate this chemistry to some extent with the element silicon which, like carbon, is tetravalent. Polymerized compounds of some complexity, based upon a silicon-oxygen linkage, have been developed, and these organosilicon compounds are known as *silicones.*

Although the chemistry of organosilicon compounds is more than a hundred years old, the production of commercial silicones only began during World War II with the formation of the Dow Corning Corp. as a jointly owned operation of Dow Chemical Co. and Corning Glass Works in 1943. All production at that time was channeled into military uses, but at the end of the war fluid silicones became generally available to industry. By 1945, both Dow Corning and General Electric Co. announced the development of silicone rubbers, and in the following year General Electric opened its own silicone-producing plant. In 1949, Plaskon, then a division of Libby-Owens-Ford Glass Co., started to use silicone-alkyd resins in paints. About that same time, Linde Air Products Co., a division of Union Carbide and Carbon Corp., began pilot plant production of silicones. Dow Corning, General Electric and Linde Air Products are the three producers of primary silicones in the United States today.

■ THE TERM "SILICONES" is a convenient designation for a diverse group of chemical compounds having a silicon-oxygen linkage somewhat analogous to the carbon linkage in organic compounds. Addition of organic side-chains often produces a material that is actually more organic than inorganic. Also, many of the commercial silicones are formulated by mixing them with silica, soaps and other fillers. Thus, the properties of materials called "silicones" may vary over a wide range. In general, however, silicones are chosen for their:

1. Resistance to deterioration at elevated temperatures. Many types can withstand temperatures of 500 F or higher for prolonged periods with little loss of important properties.

2. Maintenance of properties at low temperatures. Silicone resins and rubbers retain flexibility at low temperatures that cause other resins and rubbers to become brittle and useless. Silicone fluids show little change in viscosity in going from ordinary temperatures to low temperatures.

3. Long life. Silicones not only stand up better than organic materials under extreme temperatures, but also last longer than organic materials at intermediate temperatures.

4. Chemical inertness. Incompatibility with many chemicals is important in mold release applications, defoaming, etc.

5. Excellent resistance to deterioration during prolonged outdoor exposure. Resistance to the effects of sunlight and oxidation

TYPES OF SILICONES

Type	Forms	Significant Properties	Major Current Applications
FLUIDS ("oils")	Pure liquid or water emulsion.	Wide range of viscosities, good heat stability, high flash points, low volatility, low freezing points, good dielectric properties, wide useful temperature ranges, good water repellency, chemical inertness.	Damping fluids, hydraulic fluids, dielectric fluids, water-repellents, mold release agents, lubricants, antifoam agents, polishes or cleaners, immersion baths.
COMPOUNDS ("greases")	Fluid thickened with filler.	Same as above. Do not soften and flow readily at elevated temperatures.	Lubricants, sealants, packing impregnations, vibration dampers, mold release agents, antifoam agents, rust preventives.
RESINS	Solid in solvent solution or sometimes in water emulsion. Formulated (often with fillers and/or organic materials) for molding, laminating, coating or foaming.	Good heat stability, good dielectric properties, good water repellency, chemical inertness, good resistance to weathering and ozone.	Molded parts, electrical insulation impregnations, electrical insulating laminates, water-repellents, heat- and chemical-resistant coatings, mold release agents, foamed core structures.
RUBBERS	Solid gums, or compounds containing fillers, vulcanizing agents and additives. Rubber compounds may be (1) solid and formulated for molding, extruding, calendering or sponging, (2) in form of paste, or (3) in solvent dispersion. Also plain or reinforced sheet, tubing and extruded shapes.	Retention of useful strength and flexibility over long period at high and low temperature extremes, chemical inertness, relatively good oil resistance, good dielectric properties, good resistance to weathering and ozone.	Gaskets, electrical insulation. Fabric coatings and impregnations for both electrical and mechanical applications, including gaskets, mats, belting, hose, sleeving, diaphragms. Sealing, calking and potting compounds.

is important in paints, insulation on electric wire, etc.

6. Good water repellency. Silicone fluids and resins are used on both organic and inorganic materials where water repellency is desired. Water repellency is also important in connection with other properties such as dielectric strength.

Of even greater importance than any single property is the unique combination of properties. No other fluids have the combination of good oxidation resistance, low vapor pressure, low freezing point, good heat stability and flat viscosity curve that makes silicone fluids outstanding for aircraft instruments. No other resins or rubbers have the combination of good dielectric strength, good arc resistance, good heat stability, outstanding resistance to ozone and weathering, and good low temperature properties that make silicone resins and rubbers excellent insulation for electrical conductors.

Principal disadvantages of the silicones are high cost, incompatibility with many other substances, some processing difficulties and, in the rubbers, relatively poor strength and extensibility. Also, silicones will burn, and they are adversely affected by many petroleum compounds, particularly the aromatic hydrocarbons used in aviation fuel. Resistance to straight-chain hydrocarbon oils is good, however.

Chemical classification of the silicones is difficult. In this article chemical nomenclature has been largely omitted, and the silicones have been somewhat arbitrarily classified according to their physical state. Hence, five groups are distinguished: fluids, greases and other compounds, resins, rubbers, and specialties. Such a classification is common in the industry and provides a fairly convenient basis for considering specific applications.

Silicone Fluids and Compounds

The silicone fluids or "oils" are clear liquids having excellent stability at elevated temperatures, low freezing or "pour" points, a wide range of viscosities from about 0.65 to higher than 1,000,000 centistokes, and only small change in viscosity through a wide temperature range. They have an oily feel, but conventional types have little lubricating ability and must be used as lubricants only with caution. They are nontoxic and have little chemical reactivity, yet they are effective as additives even in very small amounts. They are colorless, or nearly so.

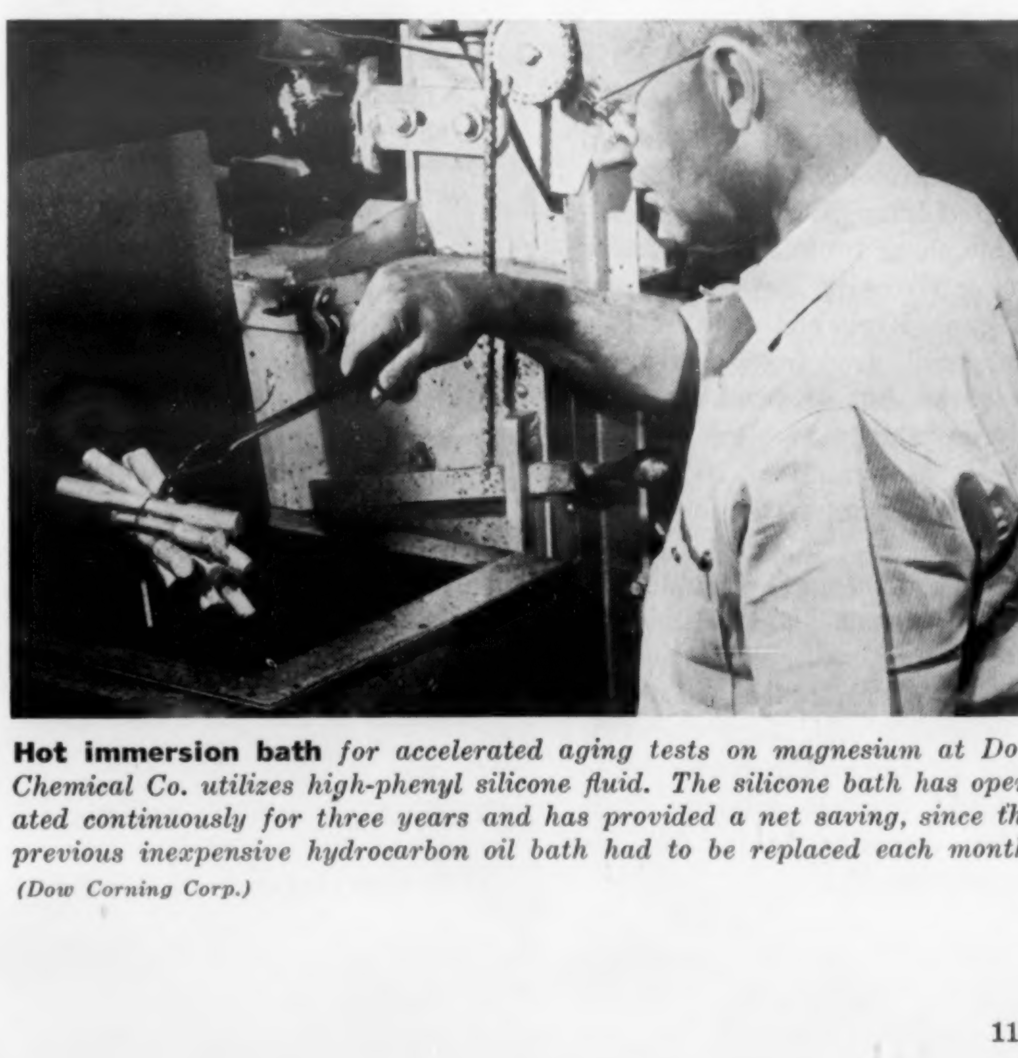
Silicone fluids may be classified in two composition groups: the dimethyl silicones, and silicones other than dimethyl. The first group has two methyl groups for each silicon atom. In the second group some of the methyl radicals are replaced by another organic radical—sometimes ethyl but usually phenyl. The phenyl types are stable at higher temperatures and have slightly better lubricity than the dimethyl silicone fluids.

Silicone fluids are used as bulk fluids, as films, and as additives to other materials. Although high in price, the amount required in many applications is so small that overall cost is often lower than that of less expensive materials. In addition, of course, silicone fluids often make possible economical designs that would otherwise be impossible.

Dimethyl silicones

The dimethyl silicone fluids are known commercially as Dow Corning "200 Fluids", General Electric SF-96 and Viscasil series, and Linde L-series. These materials can be specified by means of the commercial designation, together with the desired viscosity. Significant properties are summarized below:

Heat stability—Stable for long periods at 300 F if in contact



Hot immersion bath *for accelerated aging tests on magnesium at Dow Chemical Co. utilizes high-phenyl silicone fluid. The silicone bath has operated continuously for three years and has provided a net saving, since the previous inexpensive hydrocarbon oil bath had to be replaced each month.* *(Dow Corning Corp.)*

with air, and at 400 F if protected from air. At 475 F in air, viscosity shows considerable increase within 12 hr, and fluid is converted into, or coated with, tough rubbery gel within 48 hr (addition of antioxidant retards gel formation). Heat in the absence of oxygen breaks down fluid into polymers of lower molecular weight (slowly at 475 F, and rapidly above 650 F).

Boiling point—Lowest viscosity fluids boil in the 275 to 350 F range. Fluids with viscosity above 50 cs. are practically unboilable even at reduced pressures. Heated strongly long enough they decompose without boiling, but the lower-viscosity decomposition products may boil.

Freezing ("pour") point—Most dimethyl silicone fluids retain useful fluidity at temperatures no lower than -40 F, but some low-viscosity fluids are useful at temperatures of -100 F and lower.

Viscosity-temperature—Change in viscosity over wide temperature range is much less than for petroleum oils. For example, over the temperature range from -50 to 300 F, the viscosity of a 100-cs. fluid varies from 1000 to 25 cs. The change is small enough so that the normal viscosity index is not applicable and a new viscosity-temperature coefficient has been established.

Viscosity breakdown—Good resistance to viscosity breakdown during prolonged exposure to elevated temperatures. No measurable shear breakdown in fluids having viscosity less than about 1000 cs. Higher-viscosity fluids show small drop in viscosity under shear, but original viscosity is reestablished when shear ceases. Maximum of 10% drop in viscosity reported for 16-hr exposure.

Water resistance—Insoluble in water but not impermeable to water vapor.

Solvent resistance—Insoluble in vegetable oils. Low viscosity fluids are somewhat more soluble in other organic solvents than higher viscosity fluids. See accompanying list.

USES OF DIMETHYL SILICONE FLUIDS

DAMPING FLUID. High-viscosity fluid, together with flywheel mechanism, absorbs torsional vibration energy of crank in diesel and automotive engines. Drop of high-viscosity fluid on pivot or spindle bearings minimizes flutter of indicating needle in automotive and aircraft instruments.

HYDRAULIC FLUID subject to considerable temperature fluctuations, as in aircraft instruments and controls. Such applications have been limited because of certain lubrication difficulties encountered in conventional designs and because of incompatibility of the fluid with rubber seals. However, special rubber compounds have been developed for gaskets in prolonged contact with silicone fluids.

DIELECTRIC FLUID for transformers. Relatively noninflammable fluid with low vapor pressure makes it unnecessary to keep transformers outdoors for safety.

WATER-REPELLENT FILM for wood, rubber, glass, ceramics, and other solid surfaces. One familiar method of application: impregnated paper or "lens tissue" for cleaning spectacles. However, a much higher degree of water repellency is provided by silicone *resins*. Fluids also blended or compounded with organic resin in water-repellent film for fabrics or leather. Silicone-modified organic resin, when cured, imparts smooth, resilient "hand" to fabrics and increases their tear and abrasion resistance.

MOLD RELEASE AGENT applied by wiping or spraying. Widely used for long-lasting release film on automotive tire molds. Also used for glass molding, plastics molding, shell molding and die casting, especially of zinc parts that are not to be painted. Often applied most economically as water emulsion. Silicone fluids eliminate smoke and fumes resulting from carbonization of older petroleum-type parting agents.

LUBRICANT for plastics and sometimes rubber parts. Lubricant for metals where rolling friction is involved. Lubricant for certain metallic combinations where sliding friction is involved. Light to moderate loads only. Example: parking meters. Also used for impregnation of porous bronze bearings. Cutting fluid for machining plastics.

ANTIFOAM AGENT in processing of petroleum oils, tars, hydraulic fluids, syrups, latex coatings, paper pulp slurries and adhesives. Often used in automotive crankcase oil to reduce foaming caused by other common additives. Not applicable to solvents for silicones. Some silicone antifoam agents contain a few percent of a specially purified fine silica.

LUBRICATING FILM ON GLASS. Reduces self-abrasion of woven or unwoven fibers so cloth or mat can withstand repeated flattening without destruction. On glass bottles, inside coating reduces cracking due to impacts during filling and allows contents to be released more readily. Outside coating reduces scratching caused by contact with other bottles. Glass bottle coatings applied simultaneously by vaporizing fluid in oven.

ADDITIVE FOR RUBBER. Incorporated by special techniques into rubber, especially butadiene-styrene and chloroprene synthetics, silicone fluid improves abrasion resistance, weather resistance and stability at slightly elevated temperatures.

POLISH OR CLEANER for automobiles, furniture, windows. Often combined with waxes.

ADDITIVE FOR PAINT in amounts of about 0.2%. Reduces pigment-floating tendency, aids gloss retention, acts as antiflooding agent, and reduces orange peel.

SPRINGS that utilize the compressibility of silicone fluids.

SOME SOLVENTS FOR SILICONE FLUIDS

Amyl acetate	Kerosene
Benzene	Methylene chloride
Carbon tetrachloride	Mineral spirits
Chloroform	Naphtha
Cyclohexane	Toluene
Ethylene dichloride	Trichloroethylene
Gasoline	Turpentine
Hexyl ether	Xylene
PARTIAL SOLVENTS*	
Acetone	Ethyl alcohol
Butyl alcohol	Isopropyl alcohol
Dioxane	Orthodichlorobenzene

* *Partial solvents only for silicone oils having viscosity in 10-50 centipoises range.*

Chemical resistance—Generally inert to dilute aqueous solutions of acids and alkalies, paraffin hydrocarbons. Strong reagents such as solid ferric or aluminum chloride cause increase in viscosity and finally gel formation. Slowly destroyed by concentrated sulfuric or phosphoric acid. Slowly oxidized by concentrated nitric acid at elevated temperatures. Decomposed by gaseous hydrochloric acid or chlorine.

Effect on materials—Do not react with plastics, lacquers and other organic coatings. Fluids of low viscosity and low molecular weight are reported to cause slight leaching of plasticizer and some shrinkage in rubber subjected to prolonged immersion. Noncorrosive to metals. Prolonged contact with steel, aluminum, tin zinc, cadmium or silver has no effect on fluids. Prolonged contact with lead or tellurium at 400 F seems to increase viscosity, and prolonged contact with copper or selenium seems to decrease viscosity slightly.

Flammability—Can be ignited, but will not support combustion alone.

Dielectric properties — Vary with viscosity. Dielectric constant varies from about 2.2 to 2.8, and is little affected by change in temperature or frequency. Power factor, also little affected by temperature, remains low for frequencies up to 100 mc., then rises sharply. Volume resistivity is approximately 10^{14} ohm-cm, and is nearly constant up to about 400 F. Dielectric strength at 10 mils has been reported as 250 to 300 v per mil, and at 100 mils on the order of 500 v per mil. However, values as high as 35 to 40 kv have also been reported for thoroughly-dried fluids at a 100-mil gap.

Lubricating properties—Good for rolling friction. For sliding friction, lubricating ability of dimethyl fluids varies widely wth materials involved. Generally not suitable for steel on steel, though some light-load applications have been successful. Not suitable for steel shaft in graphite bearing. Apparently satisfactory for zinc-plated, chromium-plated, bronze or cadmium-plated (at light loads) shaft in steel bearing and for steel shaft in babbitt, silver or nylon bearing. Also suitable for plastics and rubber bearing combinations.

Compressibility—Low-viscosity fluids more compressible than mineral oils, glycerin and similar fluids. Compressibility decreases with increase in viscosity.

Other silicone fluids

The most important advantages of phenyl-containing or diethyl silicone fluids, compared to the more common dimethyl fluids, are greater heat stability and a broader useful temperature range. Some of these fluids have a freezing or "pour" point as low as -95 F combined with a flash point of 550 F. As the accom-

COMPRESSIBILITY OF SILICONE FLUIDS

Type of Fluid (Kinematic Viscosity, cs.)	Compressibility			
	Under 7100 psi	Under 35,000 psi	Under 284,000 psi	Under 568,000 psi
0.65	6.3	16.3	Freezes	—
2.0	4.9	14.3	31.5	36.9
100	4.5	12.7	28.6	34.0
1000	4.6	12.7	28.2	33.5

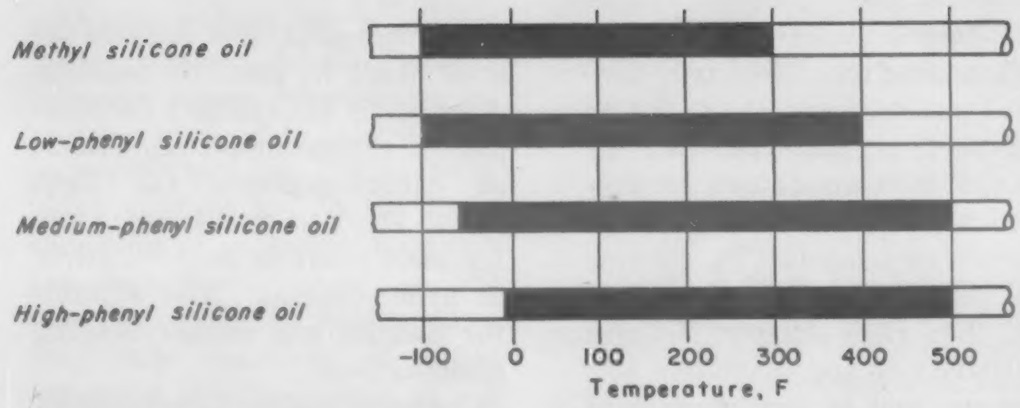
USES OF OTHER SILICONE FLUIDS

HOT IMMERSION BATH. Examples: sterilizing fluid for dental instruments that does not cause rusting and does not smoke when hot; laboratory constant temperature bath; calibration bath. A similar use: heat exchange fluid.

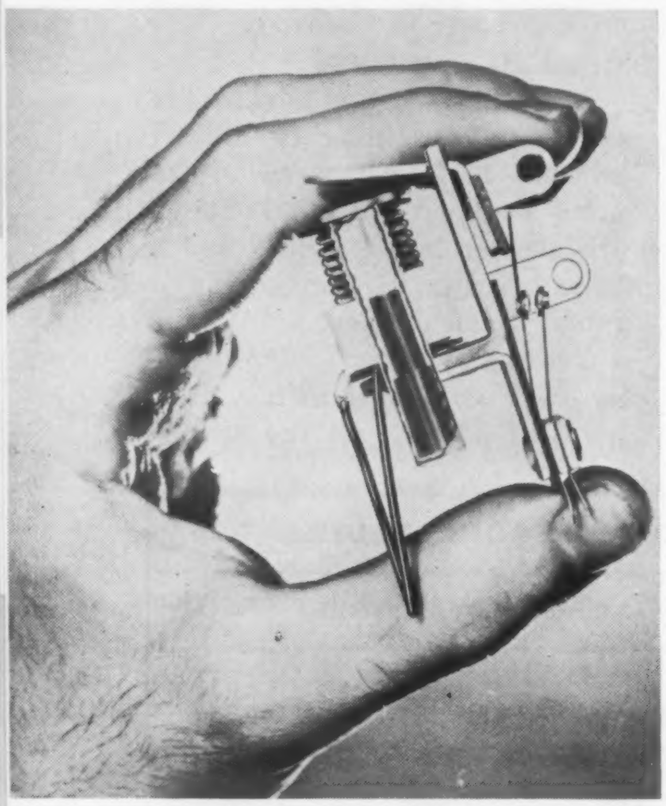
LUBRICANT FOR METALS over wider temperature range than possible with dimethtyl silicone fluids. Suitable for rolling friction and, for certain metallic combinations, sliding friction. Light loads only. Examples: permanent lubrication of electric clocks, electric razors, scientific equipment. One new fluid appears suitable for steel-on-steel sliding friction applications, heretofore not possible with silicones.

WATER-REPELLENT FILM FOR FABRICS. Fluid and resin combined in coating material that must be set with heat—a few minutes at 300 F or less than a minute at higher temperatures. Used for fabrics; also for paper used for protection or interleaving of asphalt packaging, pressure-sensitive tapes, partially cured rubber, etc.

DIFFUSION PUMP FLUID.



Useful temperature ranges for silicone fluids. *(Dow Corning Corp.)*



Relay *made by Heinemann Electric Co. utilizes silicone fluid as damping medium.* *(General Electric Co.)*

Car polish *is one of many products that have been improved by silicone fluids.* *(Linde Air Products Co.)*

panying chart indicates, many are suitable for continuous use at temperatures up to 500 F. Some can be used at higher temperatures for short periods or where a brief service life is acceptable. For example, high-phenyl fluids have been used at 700 F where relubrication of bearings was possible. Addition of an antioxidant increases service life, although the antioxidant itself is eventually destroyed at high temperatures.

Variation of viscosity with temperature is generally greater in phenyl-containing fluids, particularly in the high-phenyl fluids, than in the dimethyl fluids, but this variation is never as large as in petroleum oils. Phenyl-containing fluids are also much more compatible with organic materials than are dimethyl fluids and, consequently, are not nearly so suitable as mold release agents or as lubricants for plastics. They are also less useful as polishes.

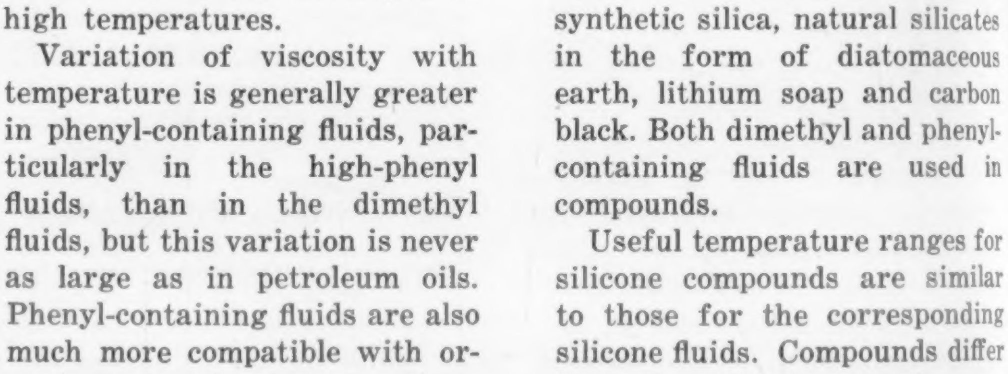
Because of the greater heat stability and broader useful temperature range, phenyl-containing fluids are sometimes preferred to dimethyl fluids as lubricants despite a steeper temperature-viscosity curve. In addition, a phenyl-containing fluid recently announced appears to be suitable for the common lubrication problem of steel-on-steel sliding friction, a type of application for which neither dimethyl nor phenyl-containing silicone fluids have previously been satisfactory. The new fluid is reported to have a useful temperature range from -100 to 500 F and a flatter viscosity curve than most phenyl-containing fluids. It can also be compounded as a grease.

Silicone compounds

Silicone compounds or "greases" are made by thickening silicone fluids by means of small filler additions. Common fillers are specially purified fine synthetic silica, natural silicates in the form of diatomaceous earth, lithium soap and carbon black. Both dimethyl and phenyl-containing fluids are used in compounds.

Useful temperature ranges for silicone compounds are similar to those for the corresponding silicone fluids. Compounds differ from the fluids in that they can be made so that they do not flow readily at temperatures up to 375-400 F. Like the fluids, they have good dielectric strength, low volatility, chemical inertness, and surface properties useful in lubrication and defoaming.

Springs *utilizing silicone fluids were developed by the Hydra Spring Div. of Wales-Strippit Corp. for use in heavy-duty punches and machine tools. They have almost 10% compressibility at 20,000 psi, and about the same capacity as a conventional spring 12 times as large and five times as heavy.* *(Dow Corning Corp.)*



USES OF SILICONE COMPOUNDS (Greases)

LUBRICANT. Dimethyl types used especially for intermittent motion in high-temperature steam or corrosive environments. Examples: pipe line valves, stopcocks.

LUBRICANT FOR METALS. Low-phenyl and some dimethyl types used especially in low temperature environments, also over broad temperature ranges and at high temperatures. Examples: motor bearings, ball bearings carrying light to moderate loads, time clocks, radar tuning devices, electricity meters and microphone switches.

LUBRICANT FOR METALS. Medium-phenyl types suitable for especially wide variety of uses, including high temperature-high speed applications, contact with corrosive liquids or atmospheres.

LUBRICANT FOR METALS. High-phenyl types, compounded with carbon black, particularly suitable for high temperature-low speed applications. Can withstand 500 F continuously, up to 1000 F for short periods. Examples: bearings in furnace cars, oven doors and oven conveyors.

SEALANT for spark plugs, switches, terminals and other electrical connections in high-flying military aircraft, X-ray equipment, etc. Prevents moisture absorption, corrosion, corona discharge. Also sealant for vacuum and distillation equipment.

PACKING IMPREGNATION to lengthen life of packing in pumps handling corrosive chemicals.

VIBRATION DAMPER. Example: phonograph pick-up.

MOLD RELEASE AGENT Even though more costly, compound sometimes preferred to fluid. Similar uses: prevents glue and resin from sticking to press platens in manufacture of plywood; prevents plastics packaging film from sticking to heating irons or heat-sealing equipment.

ANTIFOAM AGENT used in bottling soft drinks and chemicals, cooking varnishes, concentrating sugar, loading tank cars with latex or tar, etc.

RUST PREVENTIVE. New compound designed for protection of ferrous artillery components during long storage is expected to be useful for delicate instruments that might be adversely affected by ordinary rust preventives.

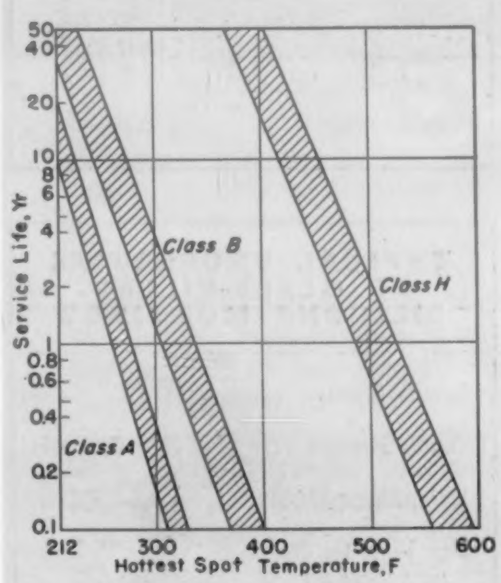
LUBRICANT FOR RUBBER. New compound has been developed for automotive door weatherstrips, hood bumpers and other parts made of rubber.

Silicone Resins

Silicone resins make the unique combination of properties characteristic of the silicone family available to the broad field known as "plastics." What is more important thus far, silicone resins, along with the commercial development of glass fibers and fabrics, have made possible the advent of Class H electrical insulation, capable of long life at continuous operating temperatures much higher than are possible with Class A or B insulation.

The most important properties of silicone resins are good heat stability, good dielectric properties, good water repellancy, chemical inertness and good resistance to weathering and ozone. Since the resins are often filled, reinforced, blended or combined with other materials, the properties of structures made from silicone resins may depend a great deal on the properties of the other materials and on their compatibility with the silicone resins.

Generally, silicone resins can be classified as molding resins, laminating resins, coating resins and foaming resins. The resins themselves are ordinarily supplied as solvent solutions or water emulsions. Like the silicone fluids and compounds, they are high in cost and are used only for special applications not otherwise feasible or where improvement in performance is sufficient to justify the additional materials cost.



Life expectancy of Class A, B and H (silicones) insulation for various "hottest spot" temperatures.
(Dow Corning Corp.)

Molding resins

Most thermosetting organic moldings, such as the phenolics, are not suitable for continuous exposure to temperatures much above 300 F. Silicone moldings, therefore, are used primarily in the 300-500 F temperature range that is out of reach for the organics.

A silicone molding compound is usually made by mixing filler with a toluene or xylene solution of the silicone resin, flashing off the solvent under a partial vacuum, drying the mixture (about 10 min at 225 F) and

breaking it up. Fillers are always used. Because most applications involve high temperatures, fillers are limited to heat-stable materials such as silica, glass, asbestos and mica. Of these, glass is most common.

At present, the cost of a silicone molding may vary considerably depending on the source of materials. Some compounds require extremely long post-cures for optimum properties. A post-cure cycle for such compounds is given in the accompanying box which outlines a typical molding cycle. Other new compounds, however, require only a 2-hr post-cure at 300-400 F for optimum properties and are usually not post-cured at all unless a high heat distortion temperature is needed. Such compounds, with molding cycles approaching those for phenolics, seem likely to broaden the industrial applications for silicone moldings.

Typical properties of a glass-filled silicone molding are shown in the accompanying table.

Laminating resins

Silicone laminates cost more than organic thermosetting laminates, and they are not as strong as the organic laminates at ordinary temperatures. However, the strength of most organic laminates drops off rapidly above 300 F, whereas silicone laminates retain most of their strength at temperatures up to 500 F and above.

Like silicone moldings, therefore, silicone laminates are confined primarily to applications involving continuous exposure to temperatures in the 300-500 F range or brief exposures to higher temperatures. They are widely used for Class H electrical insulation. Glass cloth is the most common reinforcement, although asbestos and mica are also used.

Silicone laminates and molded laminates are made by procedures similar to those used for organic laminates. Typical laminating procedures and some properties of a typical laminate are given in accompanying boxes.

One peculiar advantage of silicone laminates as electrical insulation in certain applications is the electrically insulating ash that remains even when the insulation has been completely burned. For example, the Navy found that armored cable might continue to function after a severe local fire, thus allowing a ship to return to base for repairs under its own power.

Coating resins

Silicone and modified silicone resins are widely used in paints, as nonadhesive films, and as water-repellent films.

Silicone coatings alone are serviceable at temperatures up to about 500 F. Aluminum-pigmented modified-silicone coatings can be used at 1000 F and for short periods as high as 1500 F. At such temperatures, the silicone film no longer exists as such but the pigmented paint continues to provide protection against oxidation.

In "modified" paints, silicone resins are combined with organic resins, primarily alkyd resins. The resins may be combined merely by blending or by copolymerization. Silicone additions, generally of 25% or more, improve the heat stability, gloss retention, non-yellowing properties and water repellency of conventional alkyd paints. Even a 5-10% addition improves weather resistance. Silicone-alkyd paints have top service temperatures about

TYPICAL MOLDING CYCLE FOR GLASS-FILLED SILICONE RESIN

Molding temp	300–350 F
Molding pressure	1000–15,000
Curing time in mold	10–30 min
Mold shrinkage	0.1–0.8%
Postcure (oven)	16 hr at 200 F 2 hr at 260 F 2 hr at 300 F 2 hr at 350 F 2 hr at 400 F
Cure shrinkage	0.1%

TYPICAL PROPERTIES OF GLASS-FILLED SILICONE MOLDINGS

Specific Gravity	1.7–2.0
Tensile Strength	2000–6000 psi
Water Absorp, 24 hr	0.2–0.9%
Max Temp for Continuous Exposure	450–570
Heat Distortion Temp	500–930 F
Dielectric Strength at 60 cycles/sec	100–300 volts/mil
Dielectric Constant: 60 cycles/sec	3.2–5.0
1 megacycle/sec	3.2–5.0
Power Factor: 60 cycles/sec	0.002–0.007
1 megacycle/sec	0.002–0.007
Volume Resistivity	10^{13} ohm-cm

TYPICAL PROPERTIES OF CURED SILICONE-GLASS LAMINATES

Tensile strength	35–45,000 psi
Water absorp, 24 hr	0.05–0.7%
Dielectric str, 1/8 in.	360–420 v/mil
Power factor, 100 mc	0.003

TYPICAL LAMINATING PROCEDURE FOR SILICONE-GLASS CLOTH

1. Remove any organic sizing from glass cloth by heat-cleaning.
2. Immerse cloth in solvent solution of silicone laminating resin.
3. Air-dry impregnated cloth about 30 min.
4. Further dry impregnated cloth 5-10 min at about 225 F.
5. Lay up (or wind) impregnated sheets to form sheet, rod, tube, moldings, etc.

HIGH-PRESSURE:

6. Cure laminate 1¼ hr at 350 F under 900 psi, and cool 30 min under pressure.
7. Heat 15 hr at 200 F.
8. Raise temperature to 375 F through 8 hr, and heat 16 hr at 375 F.
9. Heat 4 hr at 480 F, and cool.

LOW-PRESSURE:

6. Cure laminate at 350 F under contact pressure for 15-60 min, depending on section thickness, and cool.
7. Heat 16 hr at 200 F.
8. Raise temperature to 480 F through 4 hr, and heat 80-150 hr at 480 F.

Net contact heater *made by Pre-Fab Co. for melting 5-gal drums of plastisol has nylon-reinforced glass cord insulation impregnated with silicone resin varnish. Device was originally developed to keep high altitude aerial cameras and control mechanisms operative in sub-zero environments.* *(Dow Corning Corp.)*

Electric motor *emerges from dip tank en route to baking oven where silicone resin varnish will be cured. Overall silicone coating is final step in rewinding motor with Class H insulation.* *(Linde Air Products Co.)*

100 F lower than those for silicone films alone. However, the modified silicone films are more easily applied and quicker drying than the straight silicones.

Silicone and modified silicone paints are applied preferably by spraying. Roller coating and especially brushing are not generally recommended. Optimum properties are obtained by an elevated temperature cure. Straight silicone coatings may

USES OF SILICONE RESINS

HEAT-RESISTANT LAMINATE, primarily for use in the 300-500 F range. Especially Class H insulation. Examples: spacers and barrier sheets in dry transformers, and slot wedges, spacers and other mechanical supports in electric motors. Silicone laminates of glass, asbestos or a mica-glass cloth sandwich increase permissible operating temperatures and thereby make possible smaller, lighter transformers and motors for given output. It has been estimated that although a silicone-insulated motor costs about 75% more than a Class A or B motor of the same size, its cost based on dollars per horsepower output is about the same or sometimes less.

SILICONE PAINT OR VARNISH. Varnish used especially on electric motors, circuit chassis. Aluminum-pigmented modified-silicone paints especially suitable for use in the 300-500 F range and for brief exposures to temperatures as high as 1500 F. Examples: Stacks, stack breeching, stoves and furnaces, steam pipes, exhaust lines and sterilizing racks. Such paints often cured in service. Other types used for automobile manifolds, vehicle heaters, non-yellowing white finish for hospital equipment. Modified-silicone enamel also used as wire insulation. Results of one series of tests indicated that induction motors wound with silicone-coated wire and operating at 325-360 F had the same life expectancy as similar motors wound with Class A insulation and operating at about 190 F.

HEAT-RESISTANT MOLDING utilizing glass, asbestos or diatomaceous earth filler. Examples: switch parts, brush ring holders in electric motors, coil forms.

FOAMED LOW-DENSITY STRUCTURE made by shaping prefoamed block or sheet or by foaming resin in place. Expected applications: cores in high-speed aircraft structures and thermal insulation for other high-temperature structures.

MOLD RELEASE AGENT applied as emulsion or solvent solution. Especially effective with metal patterns in shell molding process. Another example: silicone resin coating on bakery pans lasts for weeks, eliminating cost of material and labor required to grease pan before each bake and providing net saving despite hundred-fold higher initial cost. Also makes release of baked goods from pan much easier.

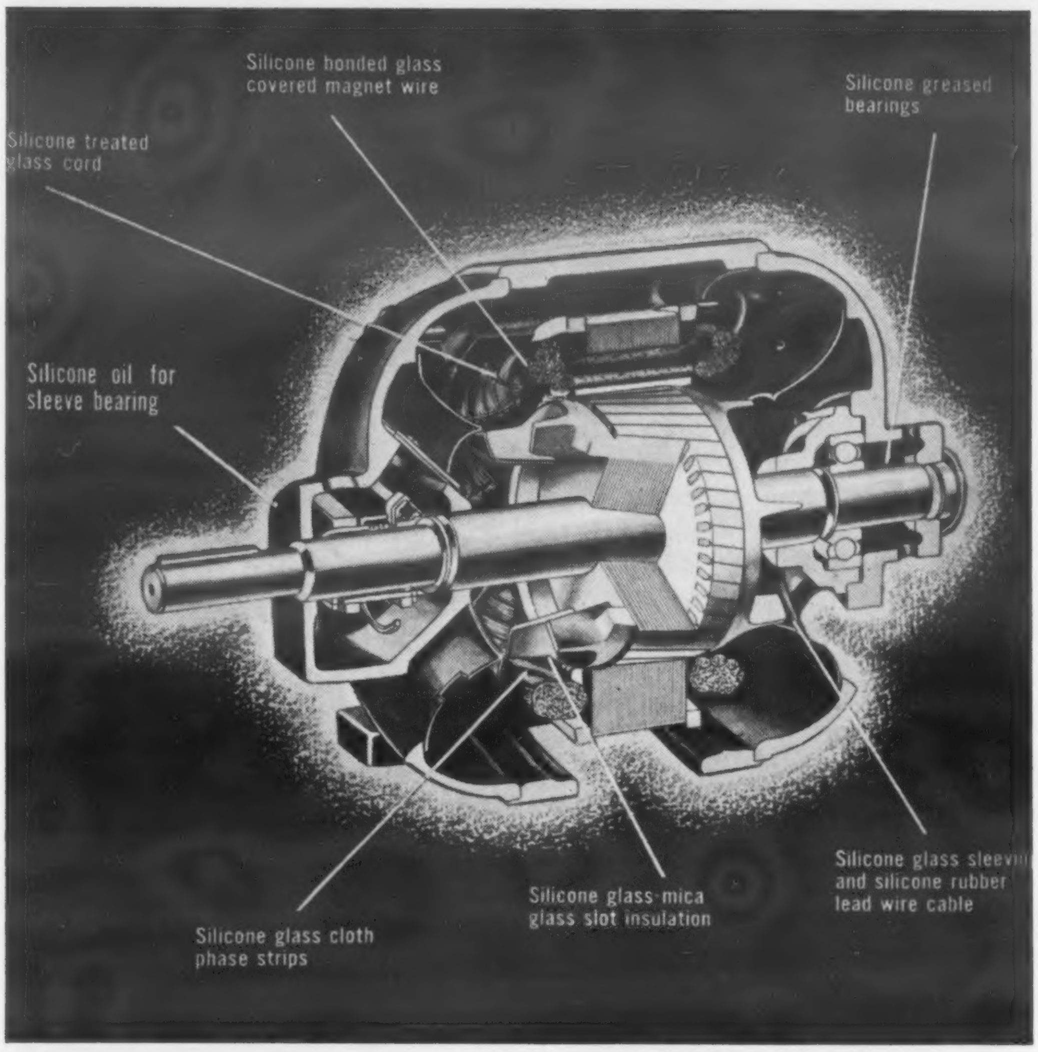
WATER-REPELLENT COATING for masonry and concrete. Provides invisible film that is permeable to water vapor and thus reduces condensation of moisture inside walls.

WETTING AGENT. Examples: Coating for alumina grits to improve bonding in resin-bonded grinding wheels. Sizing for glass cloth to improve adhesion to polyester resins in low-pressure laminates.

SPECIAL APPLICATION: chemical-resistant electrical insulation for glass radiant heating panels. Silicone insulation pattern applied to metal surface of aluminum-glass sandwich by silk screen process. Unprotected aluminum etched away by caustic soda leaving silicone-insulated aluminum heating grid.

ADDITIVE FOR PIGMENT to improve dispersion in paints, inks.

INGREDIENT OF HEAT-STABLE MOLDING COMPOUND based on organic resin. Now under development.



Electric motor—*How silicone fluids, greases, resins and rubbers increase its efficiency.* *(General Electric Co.)*

be cured in about 1 hr at 480 F or 4 hr at 400 F. Lower temperatures can be used for the modified silicones. Silicone and modified silicone paints are often cured automatically in service.

Silicone resin release films may be applied from either solvent solution or water emulsion and cured by baking. They are used for semi-permanent release applications, as on bakery pans.

Resin solutions or emulsions for water repellency applications contain about 5% or less solids as applied and are used on non-flexible surfaces. Films for masonry and concrete generally cure at ordinary temperatures.

Foaming resins

Foamable silicone resins, analogous to the foamable organic resins, are available for the production of low-density parts. Some of these silicone resins can be foamed in place and can therefore be used to form low-density cores in relatively inaccessible cavities. Other resins cannot be foamed in place but can be used to make prefoamed blocks and sheets which can be formed with woodworking tools. Both types of silicone foams are produced by application of heat at temperatures in the 260-360 F range.

Foamed silicone structures can be produced in densities ranging from 6 to 24 lb per cu ft. They are reported to show virtually no dimensional change after 20 hr exposure at 700 F, and less than 2% weight loss after 220 hr at 570 F. Prefoamed structures generally have somewhat better strength than foamed-in-place structures at elevated temperatures. However, foamed-in-place structures made from one resin retain good compressive strength at temperatures as high as 500-600 F. Moisture absorption of foamed structures after exposure in air at 96% relative humidity for 7 days has been reported as less than 0.05%. Foamed silicones are nonflammable.

For some time, silicone resin formulations for foaming in place were available only as two separate components that had to be mixed properly at time of use. Recently, however, a premixed powder has been made available. Shapes made from one of these resins can be postformed considerably when heated to about 200 F.

Silicone Rubbers

Like the other silicones, silicone rubbers have an exceptionally broad useful temperature range compared with organic materials. Silicone rubbers not only supplemented the resins in creating Class H electrical insulation for use at high operating temperatures but, at the other extreme, provided the first practical answer to gasketing problems in high-altitude military aircraft subject to prolonged subzero temperatures. Whereas other heat-resistant synthetic rubbers have poor low temperature properties, silicone rubbers make it possible to obtain good properties at both ends of the temperature scale in a single material.

Properties

The range of properties offered by silicone rubbers is indicated by the accompanying tables adapted from AMS and ASTM specifications. These and other significant properties are summarized briefly below:

Heat stability—Maintain properties indefinitely at about 300 F.

AMS STANDARDS FOR SILICONE RUBBERS[a]

Property[b]		3301B (General purpose)	3302B (General purpose)	3303C (General purpose)	3304B (Low compression set)	3305C (Low compression set)
Hardness, durometer "A"		40 ± 5	50 ± 5	60 ± 5	70 ± 5	80 ± 5
Tensile Strength (min), psi		500	500	400	500	500
Elongation (min), %		250	200	100	60	60
Tear Resistance (min), lb/in.		55	35	35	25	25
Oil Resistance: after 70 hr in ASTM Oil No. 1 at 350 F (ASTM D471-51T)[c]	Change in Durometer "A" Hardness No.	−15 to +5	−15 to +5	−10 to +5	−10 to +5	−10 to +5
	Reduction in Tensile Strength (max), %	50	40	20	20	10
	Reduction in Elongation (max), %	50	20	20	20	10
	Change in Volume, %	0 to +15	0 to +15	0 to +10	0 to +10	0 to +10
Dry Heat Resistance: after 24 hr at 450 F (ASTM D573-48)[d]	Change in Durometer "A" Hardness No.	0 to +10	0 to +10	0 to +10	0 to +10	0 to +10
	Reduction in Tensile Strength (max), %	15	10	10	10	10
	Reduction in Elongation (max), %	25	25	25	25	25
Compression Set: compressed 22 hr at 350 F (ASTM D395-49T, Method B)	Percent of Original Deflection (max)	72[e]	72[f]	60[f]	30[g]	36[g]
	Percent of Original Thickness (max)	29[e]	22[f]	18[f]	8[g]	9[g]
Low Temperature Brittleness (ASTM D736-46T)		Pass 5 hr at −85 F	Pass 5 hr at −85 F	Pass 5 hr at −70 F	Pass 5 hr at −70 F	Pass 5 hr at −70 F

[a] *Adapted from Aeronautical Materials Specifications copyrighted 1952 by Society of Automotive Engineers, Inc.*
[b] *Other requirements: satisfactory resistance to weathering, corrosion.*
[c] *Other requirements: no decomposition, no tackiness.*
[d] *Other requirements: no surface hardening, no cracking or checking when bent flat (90° on 2t radius for 3305C).*
[e, f, g] *Compressed to 60%, 70% and 75% of original thickness, respectively.*

At 400 F, hardness increases gradually and elongation decreases. Tensile strength may drop or increase slightly, depending on the particular material. Changes are rather sharp during first 20 days at temperature, then level off, indicating retention of useful residual properties. At 480 F the same changes occur, but the initial changes are greater. Subjected to excessive heat in air, silicone rubbers become hard and dry and eventually decompose as brittle materials. Heated in the absence of air, however, they become soft.

Low temperature flexibility—Ordinarily retain flexibility down to -70 F, and materials formulated especially for low temperature service can be used at -130 F or slightly below. Since low temperature flexibility is obtained by slight change in basic composition, not by addition of a plasticizer, low-temperature rubbers retain good elevated temperature properties. In ordinary silicone rubbers, hardness starts

ASTM STANDARDS FOR SILICONE RUBBERS[a]

Specification		TA 505	TA 604	TA 704	TA 805
BASIC REQUIREMENTS					
	Durometer Hardness No.	50 ± 5	60 ± 5	70 ± 5	80 ± 5
	Tensile Strength (min), psi	500	400	400	500
	Ultimate Elongation (min), %	200	100	75	50
Heat aged 70 hr at 450 F	Change in Durometer Hardness No. (max)	+20	+20	+15	+15
	Change in Tensile Strength (max), %	−30	−30	−25	−25
	Change in Ultimate Elongation (max), %	−40	−50	−40	−40
SPECIAL REQUIREMENTS					
Suffix B	Compression set after 70 hr at 300 F (max), %	50[b]	40[b]	40[b]	40[b]
Suffix E_1 (70 hr at 300 F in ASTM Oil No. 1)	Change in Tensile Strength (max), %	−20	−20	−20	−20
	Change in Ultimate Elongation (max), %	−20	−20	−20	−20
	Change in Durometer Hardness No. (max)	−15	−15	−15	−15
	Change in Volume, %	0 to +20	0 to +20	0 to +20	0 to +20
Suffix E_3 (70 hr at 300 F in ASTM Oil No. 3)	Change in Durometer Hardness No. (max)	−30	−35	−40	−45
	Change in Volume, %	+60	+60	+60	+60
Suffix F_2 (5 hr at −65 F)		Pass	Pass	Pass	Pass
Suffix L (168 hr in water at 158 F)	Change in Durometer Hardness No. (max)	−10[c]	−10	−10	−10
	Change in Volume, %	+10[c]	+10	+10	+10

[a] *Adapted from table on "Physical Requirements of Synthetic Rubber Compounds, Type T, Class TA, Temperature Resistant" in ASTM D735-52aT (Rubber and Synthetic Rubber Compounds for Automotive and Aeronautical Applications).*
[b] *Lower values can be obtained with sacrifice of tensile strength and elongation.*
[c] *These values can be met with sacrifice of tensile strength and elongation.*

TYPICAL PROPERTIES OF SILICONE RUBBERS[a]

Property \ Type	Low Compression Set (Class 300)	General Purpose (Class 400)	Extreme Low Temp (Class 500)
Hardness, Shore A durometer	50–80	50–90	40–80[b]
Tear strength, lb/in.	30–50	50–75	50–75[b]
Tensile strength, psi	570–750	570–800[c]	700–840[b]
Elongation, %	175–100	370–70[c]	350–90[b]
Compression set after 22 hr at 300 F, %	20-7	50–60	50–80
Brittle temp, (ASTM D 736, 5-hr soak), F	−80 to −65	−90 to −80	below −130 to −120
Stiffness temp, (ASTM D 797, 24-hr soak, modulus = 10,000 psi), F	−50 to −45	−60 to −45	below −120 to −110
Increase in durometer hardness no. after 70 hr at 450 F (heat stability)	6-5	6-3	5-3
Increase in volume after 70 hr in ASTM Oil No. 1 at 300 F (oil resistance), %	8-5	9-6	9-7
Increase in volume after 70 hr in water at 212 F (water absorption), %	high to <1	high to 3	high

(*Courtesy General Electric Co.*)

NOTES:
[a] *Compounds oven cured 24 hr at 480 F except where otherwise noted.*
[b] *Stocks cured 1 hr at 300 F.*
[c] *Properties can be improved with shorter cures where deformation at high temperatures is not factor*

to increase appreciably at about -20 F and rapidly at about -50 F. As hardness increases, tensile strength increases and elongation decreases correspondingly. In low-temperature rubbers, hardness starts to increase measurably at about -50 F and rapidly at about -100 F.

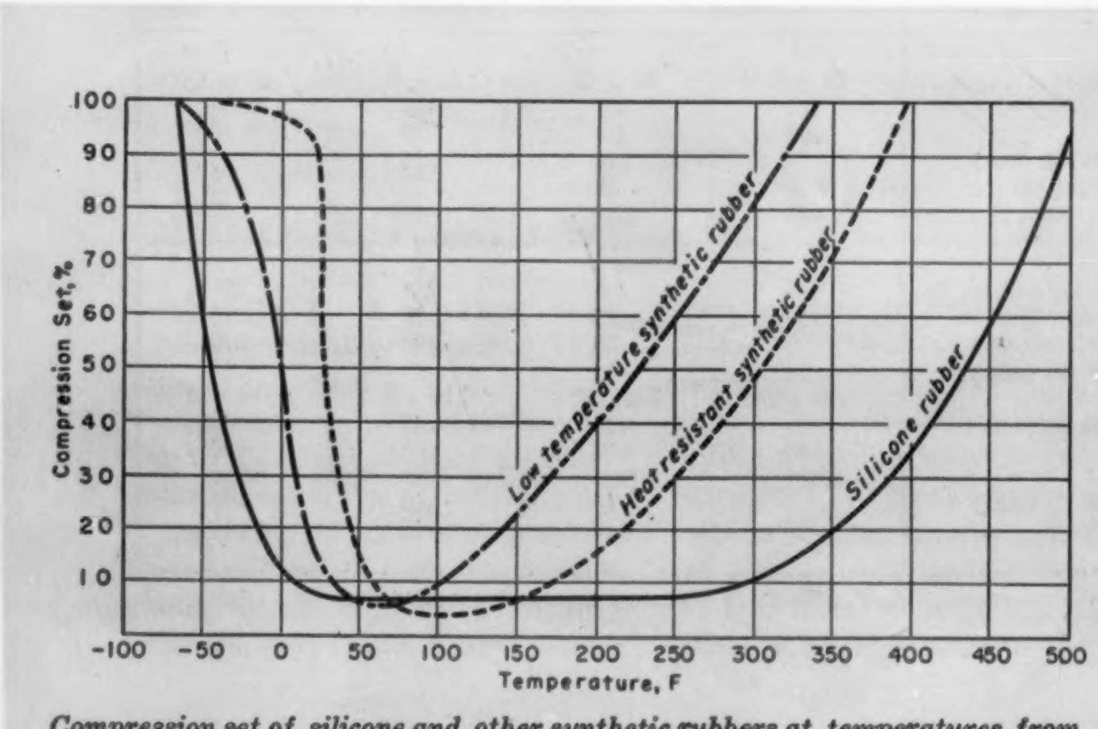
Tensile properties — At room temperature most silicone rubbers are not nearly as strong as natural and other synthetic rubbers. Tensile strength of most stocks falls in the 400-1000 psi range—about one-third the tensile strength of most natural and synthetic rubbers. However, tensile strengths up to 2000 psi are reported for some new compounds. Similarly, ultimate elongation generally ranges from 75 to 600%, but the new high-strength compounds have elongations up to 800%. Tear strength of the new compounds is also improved. In some of the new compounds, higher strengths are achieved at the sacrifice of some heat stability.

Hardness—About 35 to 95 on the Shore durometer "A" scale. Does not increase greatly until very low temperatures are reached, and is relatively constant at elevated temperatures.

Compression set—Compression set of organic rubbers is normally determined at 158 F whereas compression set of silicone rubbers is determined at 302 or 348 F. Hence, results are not strictly comparable. Silicone rubbers have a compression set of about 50%, a figure equivalent to that for heat-resistant organic rubbers. Silicone rubbers with low compression set—as low as 10% — have normally been obtained by incorporating 1 or 2% of mercury or cadmium oxides in the stock. However, a new type of silicone rubber recently announced offers compression set values in the 12-20% range inherent in the gum itself. The new rubber makes possible low compression set without special compounding and also makes low-set materials suitable for use in contact with food and beverages.

Oil resistance—Quite resistant to attack by aliphatic compounds, but swelled by exposure to aromatics. In one series of tests of lubricating oils silicone rubbers and an oil-resistant organic rubber were immersed in a low-swell oil for 72 hr at 350 F. Silicone rubbers retained 83 to 117% of original tensile strength, compared to 67% for the oil-resistant organic rubber, and 93 to 118% of original elongation, compared to 63% for the organic rubber. The silicone rubbers swelled 5 to 8%, and the organic rubber 8%.

Chemical resistance — Resist most alkalies and weak acids, corrosive salt solutions, and oils. Swell in aromatic solvents, gasoline and carbon tetrachloride. Original properties largely regained after removal from unfavorable environment and evaporation of the fluid absorbed by the rubber. Exceptional resistance to ozone, and good resistance to most aromatic chlorinated hydrocarbons (used in liquid transformers), liquid ammonia and Freon 114 refrigerants. Attacked by concentrated acids, methyl chloride and Freon 12.



Compression set of silicone and other synthetic rubbers at temperatures from —70 to 500 F. *(Dow Corning Corp.)*

Dielectric strength—Good and, in the electrical grades, reasonably constant over the temperature range up to 480 F. Since the silicones are ordinarily used fairly thick, the 800 v per mil dielectric strength of many electrical grades is satisfactory for most purposes. Stocks having dielectric strength of 1200 v per mil in low thicknesses are also available. Dielectric constant is about 3.0 to 10.0, depending on the material, and is nearly constant through a wide range of frequencies and temperatures. Power factor ranges from 0.005 to 0.028 for frequencies from 100 to 100,000,000 cycles per sec. Arc resistance is good, since the arc leaves a track of nonconductive inorganic matter instead of a path of carbonized material.

Water absorption—About 1% for most silicone rubbers, but it may be as high as 6% for some rubbers containing hydrophilic fillers.

Steam resistance—Silicone rubber hose generally has not been suitable for handling high-pressure steam, but the new low-compression-set type is reported to have much improved resistance to high-pressure steam.

Abrasion resistance — Low in most silicone rubbers but considered sufficient for most purposes. Likely to be improved with further development.

Compounding

Silicone manufacturers produce both gums and compounds. Gums are the basic silicones which must be compounded to produce commercially usable rubbers. Some fabricators prefer to buy standard compounds, while others prefer to buy the gums and formulate their own compounds.

Silicone rubber compounds consist of the following:

The gum—About six different gums, varying in chemical composition and degree of polymerization, are available.

Fillers, reinforcing agents — Silica is as important to silicone rubber as carbon black is to natural rubber. Usually it is used in the form of a fine synthetic material, but sometimes silicates in the form of diatomaceous earth are used. Manufactured silicas may be alkaline or acid, of many different particle sizes, and of varying degrees of purity. Highest tensile strengths yet reported for silicone rubbers have been obtained with a new synthetic silica filler having exceptionally low particle size.

Although silica is the most important filler for silicone rubbers, other materials are also used:

1. Calcium carbonate. Several types used, especially in coating pastes or adhesives. Not for general molding or extrusion, since tensile strength and elongation of finished stock are usually low.
2. Red iron oxide. Provides good heat aging characteristics and may be used to improve heat stability of stocks containing other fillers. Tensile strength of about 500-700 psi and elongation of about 175-250% may be expected in cured stock for coating pastes.
3. Titania. Provides good heat stability but poor reinforcement and is not much used at present.
4. Zinc oxide. Sometimes used with titania.
5. Alumina. Has produced stocks with high tensile strength and elongation in experimental work.
6. Zirconium silicate. For stocks with high tensile strength but not high heat stability. Stocks with zirconium silicate as the only filler have retained flexibility at 600 F.
7. Clay. Used with other filler such as silica to provide smoother flow in processing, especially in extruded wire insulation where mechanical strength is not important.
8. Carbon black. Sometimes used to provide black color. Has little reinforcing effect and may impair resistance to heat aging.

Vulcanizing agents (catalysts) —Benzoyl peroxide is the most common vulcanizing agent; 2,-4 dichlorobenzoyl peroxide and other peroxides are also used. They are available as powder and as pastes utilizing silicone fluids. Vulcanizing agents are used in amounts from 1 to 3% by weight of the gum. A silicone gum announced recently utilizes sulfur as the vulcanizing agent.

Special additives — Materials such as mercury oxide, cadmium oxide and 2,5 ditertiary butyl quinone are used primarily to improve compression set. Other additives may be used to improve processibility or heat aging characteristics.

Forms and fabrication

Compounded silicone rubbers are available in three different forms: solid compounds, pastes, and dispersions. The form used is determined by the nature of the product and the processing method required.

Solid compounds—A great variety of silicone rubber compounds are available, and others may be made from gums to meet special requirements. Solid compounds are processed by molding, extruding, calendering or sponging (when a blowing agent is added). Compounds are often milled for a few minutes prior to fabrication in order to improve processibility.

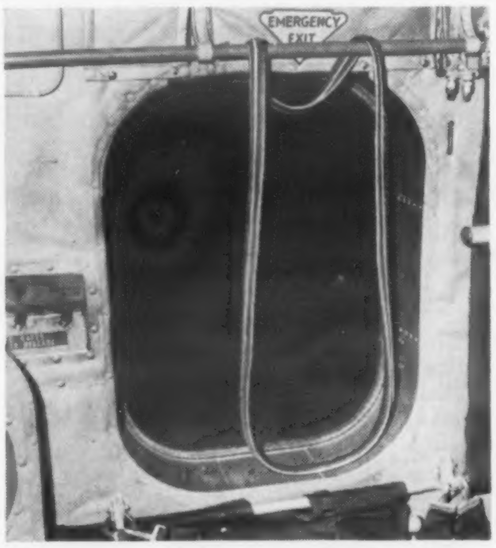
The complete vulcanization or cure of a silicone rubber is normally accomplished in two steps. The "pre-cure", which results in a certain degree of cross linking, is usually performed under pressure in a mold or in a steam vulcanizer. Some recently developed compounds are pre-cured in hot air without pressure. The final cure, or "post-cure", is done in an oven.

Molding of silicone rubber is done in heated molds at temperatures of 240 to 300 F and mold times of 3 to 20 min. In general, silicone rubber is molded at lower temperatures and shorter times than organic rubbers and, since the mold cure is normally followed by at least a short oven cure, mold time and temperature are not as critical for silicone rubber as for most organic rub-

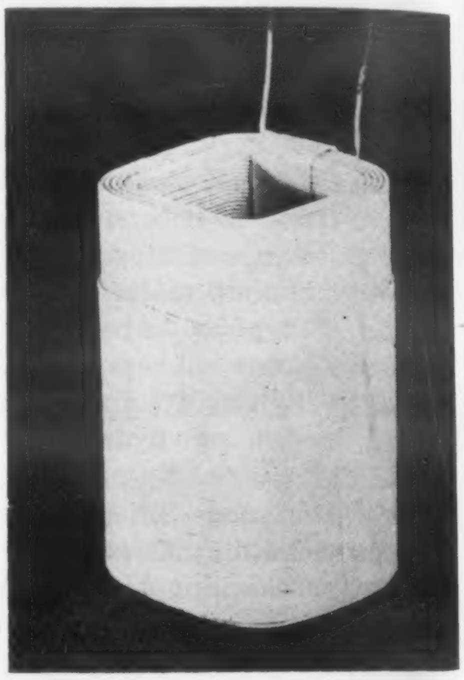
bers. Partly because of a higher coefficient of thermal expansion, most silicone rubbers have somewhat higher mold shrinkage than organic rubbers—about 3-4% for silicones compared with about 1.8-2.5% for commonly used synthetic rubbers. The subsequent oven cure increases the total shrinkage of most silicone rubbers to 5-7%. Some new silicone rubber compounds, however, have nearly the same total shrinkage as organic rubbers and can often be fabricated in molds designed for organic rubbers. The inherent nonadhesive characteristics of the silicones make mold release usually simpler for silicone rubbers than for organic rubbers. However, the silicone fluids and compounds most commonly used as release agents for organic rubbers are ineffective for silicone rubber, and dilute solutions of common detergents are ordinarily used.

Extruding of silicone rubber is done at 100 to 125 F. Since the process is exothermic, no outside heat need be added and water-cooling is sometimes necessary. Extrusion stocks are selected or compounded for smooth working in the extruder. The extruded shape is pre-cured in a steam vulcanizer under about 50 psi for about 3-15 min. Some special extrusion stocks (particularly those containing 2,4-dichlorobenzoyl peroxide as the vulcanizing agent) can be pre-cured in hot air without pressure, either in an oven or continuously in a hot air tunnel as the extruded shape emerges from the extruder. In this case, the pre-cure requires only 30-60 sec exposure to air at 600-800 F. Such a quick cure is advantageous in that it prevents collapse of the extrusion, thereby making feasible difficult shapes and closer tolerances.

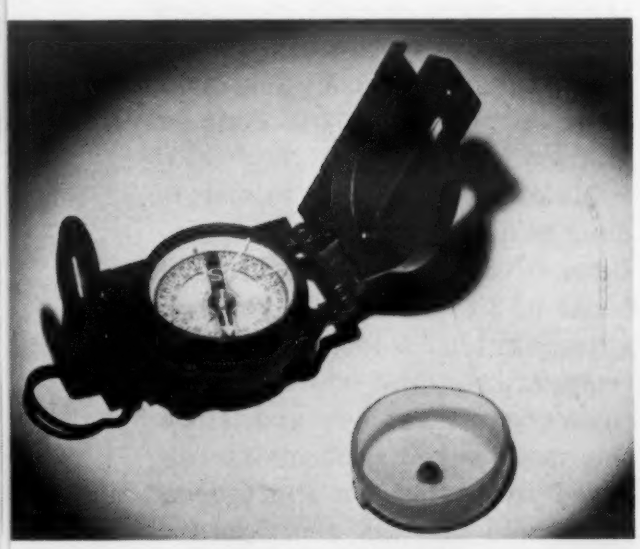
Calendering is normally done on unheated rolls, although the top roll of the three- or four-roll mill is sometimes warmed slightly. Pre-cure of sheet stock is similar to that for extruded stock. Calendering may be used to produce sheet stock or, often, to calender silicone rubber on to supporting fabrics such as glass, Dacron, Orlon or nylon cloth. Asbestos fibers and wire are also used sometimes as supporting materials. The post-cure for supported sheet stock, of course, is



Gaskets *for emergency hatches and other fuselage fittings on Douglas C-124 Globemaster are made of special silicone rubber that remains flexible at temperatures down to —120 F and does not stick to metal after long inactivity.* *(General Electric Co.)*



Coil *subject to operating temperatures as high as 600 F utilizes silicone rubber as encapsulating compound.* *(General Electric Co.)*



Pocket compass *operates over a temperature range of —85 to 160 F, is protected against moisture and shock by silicone rubber molded cup, shown in foreground.* *(General Electric Co.)*

Heater ducts *made of glass cloth coated with silicone rubber.* *(General Electric Co.)*

limited by the heat stability of the supporting material. Calendered stock, both supported and unsupported, may be used in sheet form or formed into hose or tubing by mandrel wrapping.

Sponging of silicone rubber is done by heating a suitable compound which contains a blowing agent. Blowing agents are usually proprietary compounds which produce nitrogen gas upon heating. Sodium bicarbonate, which produces carbon dioxide, is also used.

For some silicone applications no heat treatment of the compound beyond the pre-cure is necessary, but for most applications an additional post-cure in a circulating-air oven is a prerequisite for optimum properties. Essentially, the post-cure eliminates volatile substances, some of which are products of the initial vulcanization reaction and some of which are volatile silicones. Volatile substances must be eliminated to assure stable performance at high temperatures.

The post-curing cycle depends on a number of factors, including the particular compound used, the shape and cross-section of the part, and the expected service conditions. Although few broad rules can be stated, it is generally true that a silicone rubber part should be post-cured at a temperature approximately equal to the highest temperature it will encounter in service. Recommended cure time increases as cure temperature increases, e.g., from possibly 1 hr at 300 F to the commonly-specified 24 hr at 480 F. The longer oven cure normally results in lower compression set and elongation, higher durometer hardness, and better oil and solvent resistance. Other properties, such as tensile strength, vary with the particular compound.

The so-called "full" oven cure of about 24 hr at 480 F is recommended for any part which is expected to be subject to particularly severe deformation, particularly compression, in order to develop maximum resistance to compression set. On the other hand, a part which is to be subjected to negligible stresses at service temperatures even as high as 500 or 600 F can often (depending upon the compound) be used with little or no oven cure, since the post-cure, in effect, occurs in service.

Pastes—Silicone rubber pastes, varying in consistency from soft or salvelike to stiff or puttylike, make possible additional fabrication techniques, as well as certain special applications.

Thin pastes having a Williams plasticity of about 10-40 can be applied directly to fabrics with a doctor blade. When applied to inorganic materials, such as glass cloth, wire cloth or asbestos cloth, the paste is cured for 3-10 min at 400-600 F in an oven or tower. When applied to organic fabrics, such as cotton, nylon, Orlon or Dacron, a lower-temperature cure is used—usually 10-15 min at 260-300 F.

Thicker pastes having a Williams plasticity of about 40-90 are used for sealing or calking and, to some extent, potting. Some of the newer pastes, primarily those filled with calcium carbonate, have appreciably better abrasion resistance than earlier pastes. The heavier pastes are usually cured 15-30 min at 250-275 F.

Pastes may be used to coat metal, glass or ceramic surfaces. Such surfaces require careful precleaning. Solvent degreasing followed by sandblasting or shot blasting is recommended for metals, and increased adhesion is obtained by means of a special silicone primer, especially on copper and copper alloys.

Dispersions—Thick pastes (described above) in the form of solvent dispersions are used to coat fabrics, mats or solid surfaces by dipping, spraying or brushing. The solvent dispersion technique is also replacing the older thin paste technique for knife coating of fabrics because of the superior properties of the resulting coatings.

Solvents used are primarily xylol or toluol. Dispersions for dip coating usually contain about 20-25% solids, and for knife or roller coating about 35-50% solids. Knife or roller coating produce thicker films than dip coating.

After the coating has been applied, the solvent must be driven off and the solid film cured. Evaporation of solvent should take place at a temperature no higher than 170 F and preferably at the

USES OF SILICONE RUBBERS

MOLDINGS, EXTRUSIONS, AND DIE-CUT PARTS. Especially gaskets for bomb-bay doors and other aircraft openings, domestic steam irons, kitchen ranges, autoclaves and pressure cookers, searchlights.

COATED FABRICS. Silicone rubber applied as paste or solvent dispersion to glass, asbestos, wire, cotton, nylon, Orlon or Dacron, and cured. Applications: gaskets, diaphragms, belting, sleeving, hose, tubing, mats, flexible couplings.

LAMINATE OR MOLDED LAMINATE made from fabric bonded to extruded or calendered silicone rubber or silicone sponge rubber, especially for aircraft gaskets and seals.

ELECTRICAL INSULATION for motor lead wires, cables and other external conductors where high operating temperatures, moisture or corona discharge are encountered.

SEALING, CALKING AND POTTING PASTE. Example: embedment of aircraft heating and de-icing elements.

NON-STICK PARTS. Examples: Sleeves for rolls of machines processing pressure-sensitive tape or applying adhesives. Guide wheel handling hot glass sheet and tubing in glass manufacture.

NON-STICK OR WATER-REPELLENT COATING applied as paste on metal, glass or ceramic surface.

VIBRATION DAMPER. Silicone sponge rubber used for shock absorption, vibration dampening and soft low temperature sealing.

COATING FOR ORGANIC RUBBERS to extend useful temperature range, protect against oxidation and corona discharge.

lowest temperature practicable. Incomplete removal of solvent, on the other hand, may result in incomplete vulcanization. Cure time and temperature are interrelated, cure time being shorter at higher temperatures. With an organic fabric base, cure temperature may be limited by the endurance of the fabric. Films up to 5 mils thick may be pre-cured 5-10 min in an air-circulating oven or tower at 250-300 F and post-cured 5-10 min at 400-600 F. Heavier films should be applied as separate coats, and each coat separately and completely cured.

Reclaimed Silicone Rubber— Silicone rubber scraps, trimmings and rejects can be reclaimed and combined with new stock in amounts of 10 to 30%. The lower the degree of cure of the scrap the more readily it can be reclaimed. One method is to merely work the scrap for some time on rolls at about 120-125 F, then mill it together with the virgin rubber. Another method is to grind the scrap to about 5-10 mesh size, autoclave it at 50-100 psi to break some of the chemical bonds, air-dry it, work it on a mill until it is soft, and then mill it together with the virgin rubber. Amounts of about 10-15% of reclaim prepared by this latter method reduce mold shrinkage, improve compression set slightly, and cause no loss in tensile strength or elongation.

Bonding—Silicone rubber can be bonded to most materials other than plastics and organic rubbers. Bonding techniques differ depending on whether the silicone rubber is cured or uncured. To bond uncured silicone rubber to metal, glass or ceramic (or to another uncured silicone rubber) the two materials (with clean surfaces) are placed in contact and molded together by means of the normal silicone curing schedule described previously. An improved bond can often be obtained by applying a silicone resin primer to the nonsilicone surface and allowing it to air-dry before bringing the two materials into contact. To bond cured silicone rubber to a solid nonsilicone material or to another cured silicone rubber, the two materials (with clean surfaces) are brought together under pressure with a 5-15 mil sheet of thoroughly-worked uncured silicone rubber between them. The sandwich is then subjected to the normal silicone curing cycle. A 5-10 mil layer of silicone rubber paste may be used instead of the uncured sheet, and improved adhesion may often be obtained by means of a silicone resin primer. This method is also suitable for joining two nonsilicone materials with a silicone rubber adhesive.

Silicone specialties

The bonding methods described above are not always feasible, and a variety of silicone adhesives have been developed. These adhesives can be brushed on to the surfaces to be joined and cured to provide good bond strengths. Some of them require a heat-and-pressure cure, but others, if allowed to air-dry before the parts are pressed together, will cure at room temperature under contact pressure. A recently developed adhesive, for example, develops good bond strength within 24 hr and maximum strength within 3-7 days. It has good heat stability and creep strength up to 212 F. It will bond silicone rubber to itself or to aluminum, magnesium, stainless steel, butyl synthetic rubber or saran rubber. Its bond with silicone extrusions is better than its bond with silicone moldings. Specifically, a peel strength of 15 lb per in. has been obtained between extruded silicone and aluminum, compared to a peel strength of 9 lb per in. between molded silicone and aluminum.

A pressure-sensitive silicone adhesive is also available for application to tape. Pressure-sensitive silicone adhesive tape is expected to be useful as electrical insulation.

No article on silicones would be complete without some reference to the most widely known silicone of them all—bouncing putty. That strange material became an interesting novelty because of its ability to deform as a plastic material in response to slow, mild pressure, to bounce as an elastomeric material when dropped, and to shatter as a brittle material when struck a hard blow. For some time it seemed there were no practical applications for the material, but in recent years a few have been discovered. Among the most important are cores for golf balls, leveling pads for furniture, and a clutch fluid.

Acknowledgement

For their generous assistance in the preparation of this manual and for their careful review of the manuscript, the author wishes especially to thank the personnel of:

Dow Corning Corp., Midland, Mich.

General Electric Co. (Silicone Products Dept.), Waterford, N. Y.

Linde Air Products Co. (div. of Union Carbide & Carbon Corp.), New York City

The help provided by the personnel or literature of the following companies is also gratefully acknowledged:

Barrett Div., Allied Chemical and Dye Corp., New York, N.Y.

Connecticut Hard Rubber Co., New Haven, Conn.

E. I. du Pont de Nemours and Co., Inc., Wilmington, Del.

Firestone Tire and Rubber Co., Akron, Ohio

Midland Industrial Finishes Co., Waukegan, Ill.

Minnesota Rubber and Gasket Co., Minneapolis, Minn.

Monsanto Chemical Co., St. Louis, Mo.

MATERIALS ENGINEERING FILE FACTS

MATERIALS & METHODS · FEBRUARY 1955 · NUMBER 294

Melting Points of Metals and Their Oxides

METAL OR ALLOY	MELTING POINT		OXIDE SYMBOL	MELTING POINT		REMARKS
	C	F		C*	F	
Aluminum	660	1220	φ-Al_2O_3	2020	3668	—
Antimony	630.5	1175	β-Sb_2O_3	655	1221	st. >1058 F
Barium	710	1310	BaO	1920	3488	—
Beryllium	1283	2341	BeO	2520	4568	—
Bismuth	271.3	520.3	β-Bi_2O_3	817	1503	st. >1310 F
Boron	2150	~3902	B_2O_3	577	1071	—
Cadmium	321	610	—	—	—	—
Calcium	850	1562	CaO	2570	4658	—
			CaO_2	d 400	d 752	
Carbon	3700	6692	—	—	—	Graphite
Cerium	~793	~1460	CeO_2	1950	3542	CeO_2 d 4172 F
Cesium	29.8	98.6	Cs_2O	490	914	—
			Cs_2O_3	594	1101	Cs_2O_2 d 1760 F
Chromium	1870	3398	Cr_2O_3	2440	4424	—
			CrO_2	d 435	d 815	—
			CrO_3	187	369	CrO_3 d 482 F
Cobalt	1495	2723	CoO	1810	3290	—
			Co_3O_4	d 910	d 1670	—
Columbium	2415	4376	φ-Cb_2O_5	1460	2660	st. >2192 F
Copper	1083	1981	Cu_2O	1230	2246	CuO d 1886 F
			CuO	d 1030	d 1886	—
Gallium	30	86	β-Ga_2O_3	1725	3137	—
Germanium	959	1758	β-GeO_2	1115	2039	st. >1892 F
Gold	1063	1948	—	—	—	—
Hafnium	~2053	~3727	HfO_2	~2900	~5252	st. <3092 F
Indium	157	315	In_2O_3	>2000	>3632	—
Iridium	2454	4449	IrO_2	d 990	d 1814	—
Iron	1539	2802	FeO	1371	2500	—
			Fe_3O_4	1457	1655	—
Lanthanum	835	1535	La_2O_3	2320	4208	—
Lead	327	621	β-PbO	885	1625	PbO-st. >986 F
			Pb_3O_4	d 530	d 986	—
			PbO_2	d 315	d 599	—
Lithium	180	356	Li_2O_2	d 160	d 320	—
Magnesium	650	1202	MgO	2800	5072	—
			MgO_2	d 50	d 122	—
Manganese	1245	2273	MnO	1790	3254	—
			β-Mn_3O_4	1580	2876	st. >2138 F
			φ-Mn_2O_3	d 940	d 1724	—
			φ-MnO_2	d 510	d 950	—
Mercury	−38.7	−87.7	HgO	d 430	d 806	—
Molybdenum	2620	4752	$MoO_{2.88}$	d 750	d 1382	—
			MoO_3	795	1463	—

SYMBOLS: *st.—stable.*
d —decomposes.

REFERENCES: *O. Kubaschewski and B. E. Hopkins, "Oxidation of Metals and Alloys", Academic Press, Inc., Publishers, New York, 1953.*
The International Nickel Company, Inc., "Properties of Some Metals and Alloys", New York, 1951.
C. A. Hampel, "Rare Metals Handbook", Reinhold Publishing Corp., New York, 1954.
A. H. Sully, "Chromium", Academic Press, Inc., New York, 1954.
W. H. Kohl, "Materials Technology for Electron Tubes", Reinhold Publishing Corp., New York, 1951.

Continued on page 129

Melting Points of Metals and Their Oxides (Continued)

METAL OR ALLOY	MELTING POINT C	MELTING POINT F	OXIDE SYMBOL	MELTING POINT C	MELTING POINT F	REMARKS
Nickel	1455	2651	NiO	1960	3560	—
Osmium	(2700)	(4892)	OsO_2	d (650)	d (1202)	—
			OsO_4	42	108	—
Palladium	1552	2826	PdO	d 790	d 1454	—
Platinum	1773.5	3224	—	—	—	—
Potassium	63.5	146	K_2O_2	490	914	—
			β-KO_2	380	716	st. >169 F
Rhenium	3130	5666	Re_2O_7	296	565	—
Rhodium	1966	3571	Rh_2O	d 1030	d 1886	—
			RhO	d 1020	d 1868	—
			Rh_2O_3	d 990	d 1814	—
Rubidium	39	102	Rb_2O_2	570	1058	—
			Rb_4O_6	490	914	—
			RbO_2	412	774	—
Ruthenium	2500	4532	RuO_2	d 1000	d 1832	—
			RuO_4	27	81	—
Silicon	1440	2624	β-quartz	1610	2930	st. 1067-1598 F
			β-cristobalite	1713	3115	—
Silver	960.5	1769	Ag_2O	d 145	d 293	—
Sodium	97.7	208	Na_2O	—	—	—
Strontium	770	1418	SrO	2450	4442	—
			SrO_2	d 170	d 338	—
Tantalum	2996	5425	Ta_2O_5	>1900	>3452	—
Tellurium	452	846	—	—	—	—
Thallium	303	577	TlO_2	d 490	d 914	—
			Tl_2O_3	715	1319	—
Thorium	1840	3344	ThO_2	2950	5342	—
Tin	231.9	449.4	SnO	~1040	~1904	—
			Sn_3O_4	d 1100	d 2012	—
Titanium	1690	3074	β-TiO	2020	3668	st. >1814 F
			β-Ti_2O_3	2130	3866	st. >392 F
			TiO_2	1860	3380	—
Tungsten	3410	6170	WO_2	1580	2876	—
			β-WO_3	1470	2678	—
Uranium	1133	2071	UO_2	2700	4892	—
Vanadium	1900	3452	VO	2050	3722	—
			VO_2	1350	2462	—
			$V_{12}O_{26}$	670	1238	—
			V_2O_5	660	1220	—
			V_2O_3	>2000	>3632	—
Tungsten	3410	6170	WO_2	1580	2876	—
			β-WO_3	1470	2678	—
Zinc	419.5	787.1	ZnO	~1975	~3587	—
Zirconium	~1830	~3325	β-ZrO_2	2715	4919	—

SYMBOLS: *st.—stable.*
d —decomposes.

REFERENCES: *O. Kubaschewski and B. E. Hopkins, "Oxidation of Metals and Alloys", Academic Press, Inc., Publishers, New York, 1953.*
The International Nickel Company, Inc., "Properties of Some Metals and Alloys", New York, 1951.
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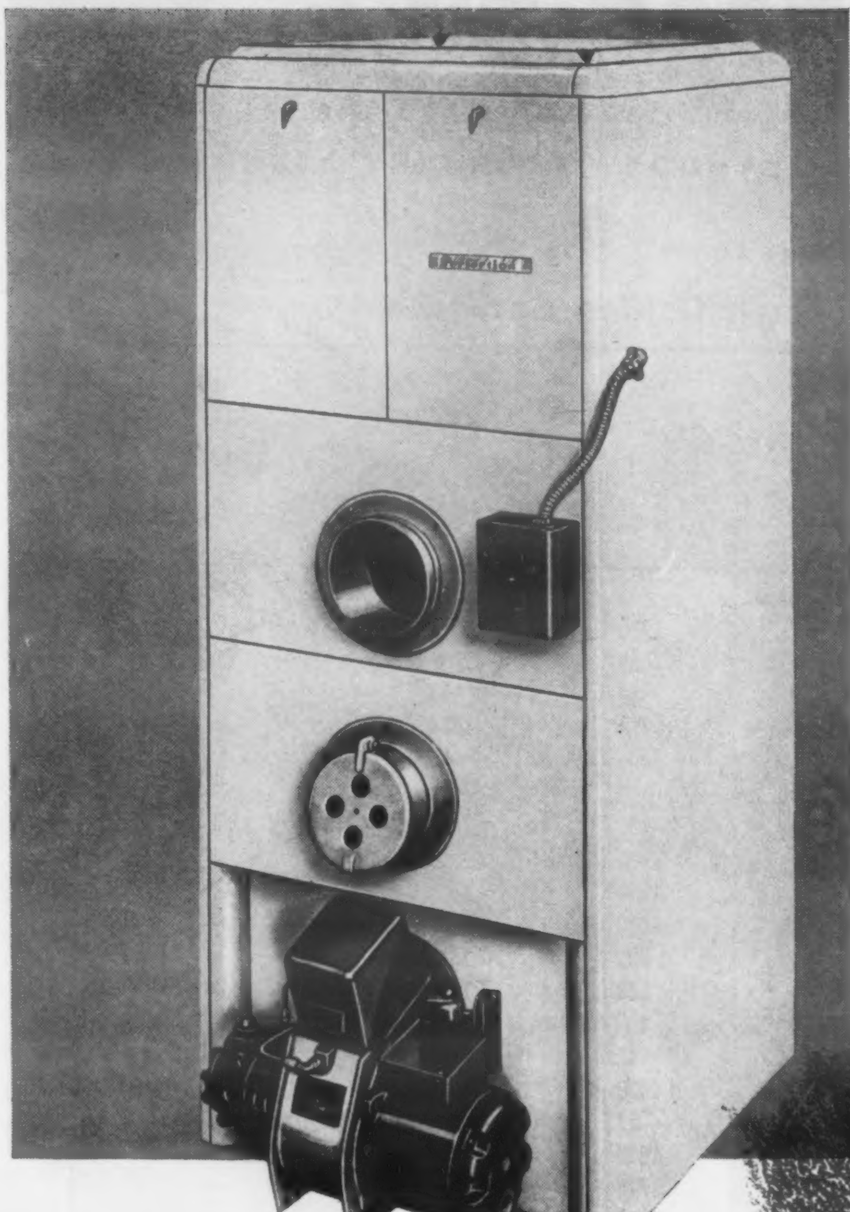
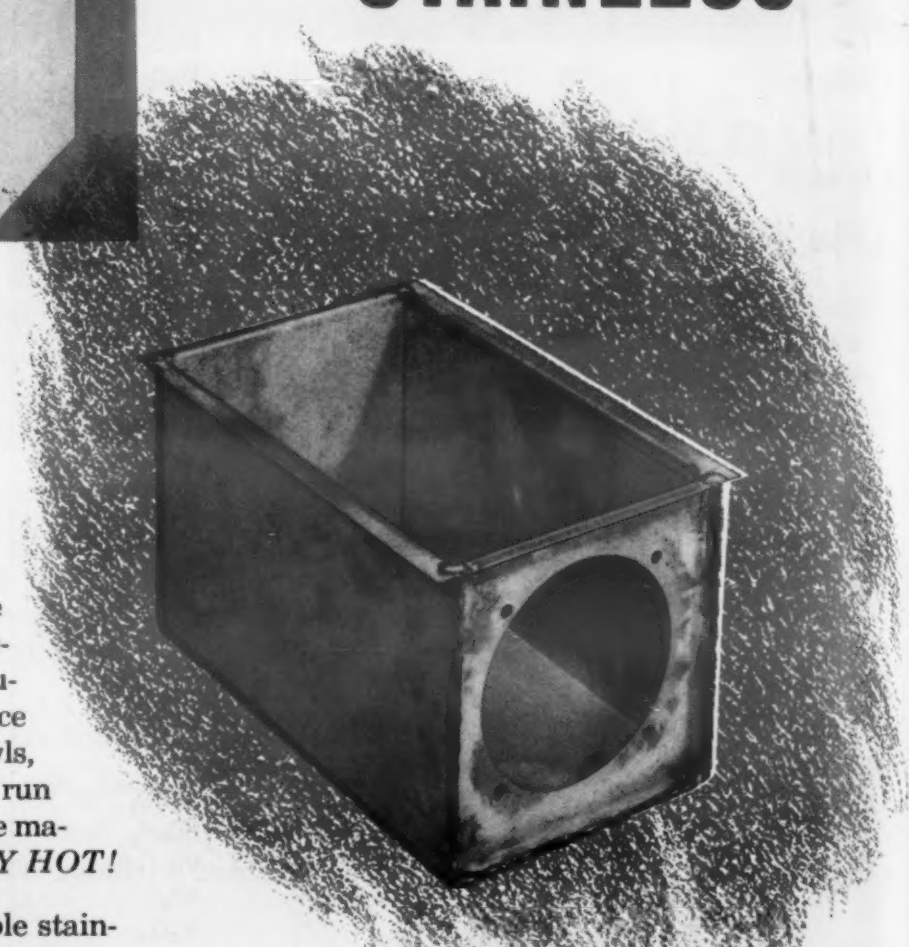


If it's meant to get

HOT

...use

CRUCIBLE STAINLESS



Crucible Type 430 firebox for the Perfection OC 90V Oil-Fired Furnace.

Say *"stainless steel,"* and most everyone thinks of bright appearance . . . corrosion resistance . . . strength without excess weight. But these properties are actually secondary in some applications.

As an example, take stainless steel's remarkable resistance to heat. That's the reason why The Perfection Stove Company uses types 309 and 430 Crucible stainless steels for its gas- and oil-fired furnace components — fireboxes, throat and burner bowls, combustion chambers, and baffles. In the long run stainless is the most dependable and least expensive material they can use for these parts that get *REALLY HOT!*

Of course, in addition to heat resistance, Crucible stainless steels offer corrosion resistance . . . high fatigue, creep and structural strength . . . resistance to wear . . . and excellent workability. And at Crucible, stainless steels are made by specialists who are concerned only with special purpose steels. They welcome the opportunity to help you select the best grade for the job. *Crucible Steel Company of America, Henry W. Oliver Building, Pittsburgh 30, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

For more information, turn to Readers Service Card, Circle No. 470

MATERIALS ENGINEERING FILE FACTS

MATERIALS & METHODS · FEBRUARY 1955 · NUMBER 295

Adaptability of Metals to Spinning

Most metals, with the exception of magnesium and molybdenum, can be cold spun. Metals, such as gold, silver, platinum, kovar, invar and ilium can be spun, but require special handling.

The adaptability of metals to the spinning process is rated in the chart given below. The unit 1.00 is assigned to the type of material in each classification that lends itself most readily to forming by the cold metal spinning process. The lower the percentage figure, the higher the cost. These figures will vary slightly with contour, gage and size.

This analysis applies to manual metal spinning by the cold method. Where quantities warrant special automatic spinning setups or where existing automatic setups can be used, difficult-to-form metals such as Type 466 chromium iron or Haynes Stellite 25 can be deep spun readily. The deep spinning ratings in the table do not apply under these conditions.

MATERIAL	SHALLOW SPINNING	DEEP SPINNING
GROUP I—ALUMINUM AND ALUMINUM ALLOYS		
1100-0	1.00	1.00
3003-0	1.00	0.99
2024-0	0.65	0.45
5052-0	0.80	0.55
6061-0	0.90	0.80
GROUP II—COPPER AND COPPER ALLOYS		
Copper, cold rolled, annealed	1.00	1.00
Copper, hot rolled	0.99	0.88
Yellow Brass	0.99	0.92
Cartridge Brass, 70%	0.99	0.92
Low Brass, 80%	0.96	0.89
Red Brass, 85%	0.90	0.83
Commercial Bronze, 90%	0.88	0.80
Gilding, 95%	0.85	0.75
Admiralty	0.82	0.70
Naval Brass	0.75	0.45
Muntz Metal	0.55	0.30
Phosphor Bronze, Grade A	0.85	0.40
Phosphor Bronze, Grade C	0.85	0.45
Cupro Nickel, 30%	0.95	0.65
Nickel Silver, Grade A	0.95	0.65
Silicon Bronze	0.94	0.60
GROUP III—CARBON AND LOW ALLOY STEELS		
Cold rolled, deep drawing quality	1.00	1.00
Vitreous enameling, deep drawing and spinning quality	1.00	0.95
Standard cold rolled	1.00	0.92
Hot rolled, pickled and oiled	1.00	0.92
Hot rolled, low carbon	0.90	0.55
Hot rolled, copper bearing	0.88	0.51

MATERIAL	SHALLOW SPINNING	DEEP SPINNING
GROUP III—CARBON AND LOW ALLOY STEELS (Continued)		
Lead coated (Long Terms)	1.00	*
Galvannealed	1.00	*
Galvanized	0.90	*
High strength steels	0.45	0.15
Carbon Steels, 0.40% and above	0.25	0.10
GROUP IV—STAINLESS STEELS		
302	0.98	0.60
304	0.98	0.90
305, free spinning	1.00	1.00
3095	0.80	0.45
316	0.90	0.60
321	0.85	0.50
347	0.90	0.50
430	0.90	0.50
GROUP V—NICKEL AND NICKEL ALLOYS		
Monel, spinning quality	1.00	0.90
Monel, special cold rolled, soft temper	1.00	0.85
Inconel	0.90	0.70
Nickel, low carbon	1.00	1.00
Nickel	1.00	0.92
Multimet N-155	0.90	0.50
Hastelloy A	0.75	0.35
Hastelloy B	0.70	0.30
Hastelloy C	0.50	0.10
GROUP VI—MISCELLANEOUS METALS		
Lead	0.96	0.90
Pewter	1.00	0.99
Zinc	1.00	1.00
Tantalum	0.86	0.45
Magnesium	0.80	0.45
Molybdenum	0.55	0.15

*SUMMARY***

Aluminum 1100-0	*1.00*
Zinc	*0.94*
Steel, cold rolled, deep drawing quality	*0.91*
Copper, cold rolled, annealed	*0.87*
Nickel, low carbon	*0.86*
Stainless Steel Type 305	*0.70*

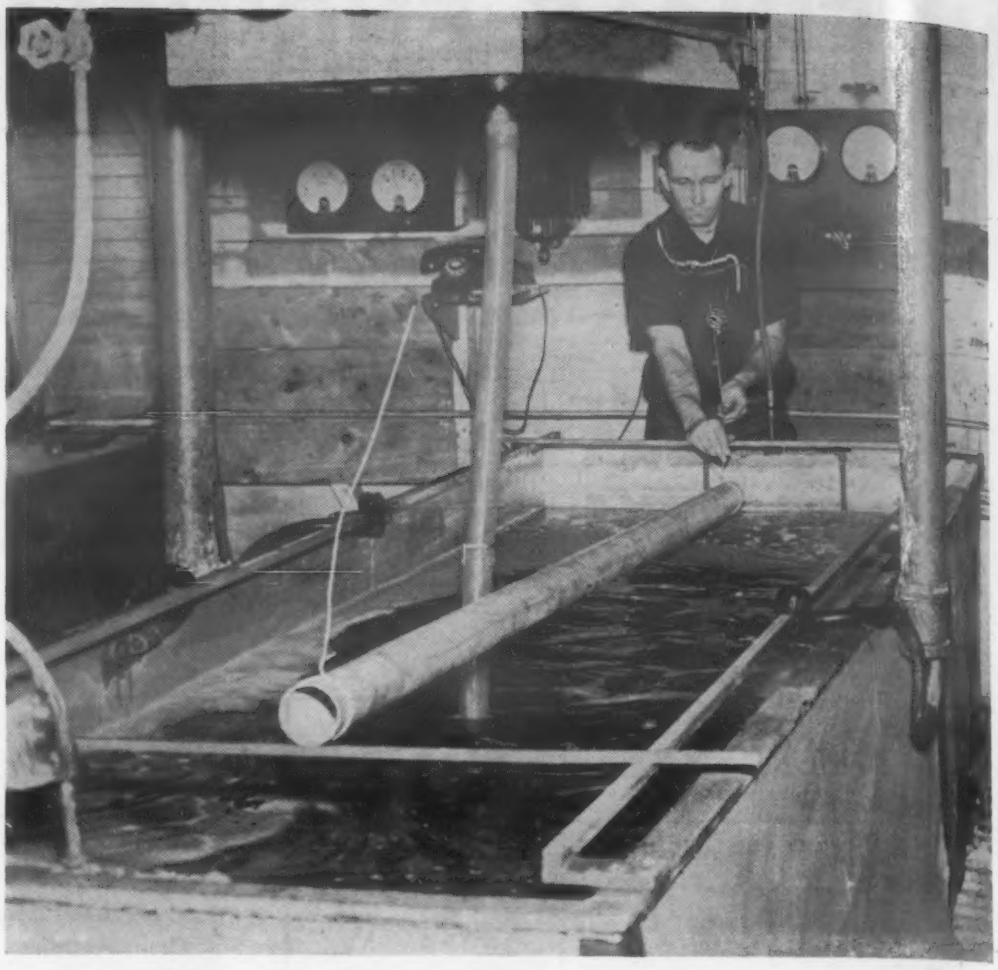
* *Impractical—coating flakes off.*

** *Relative ease of spinning vest metal each group.*

CORRECTION:

The File Facts appearing in January, starting on pages 129 and 131 were numbered incorrectly. They should have been 292 and 293 respectively, not 291 and 292.

Courtesy of Spincraft, Inc.



Aluminum tube *is lowered into the cold acid electrolyte.*

Heavy Oxide Coating

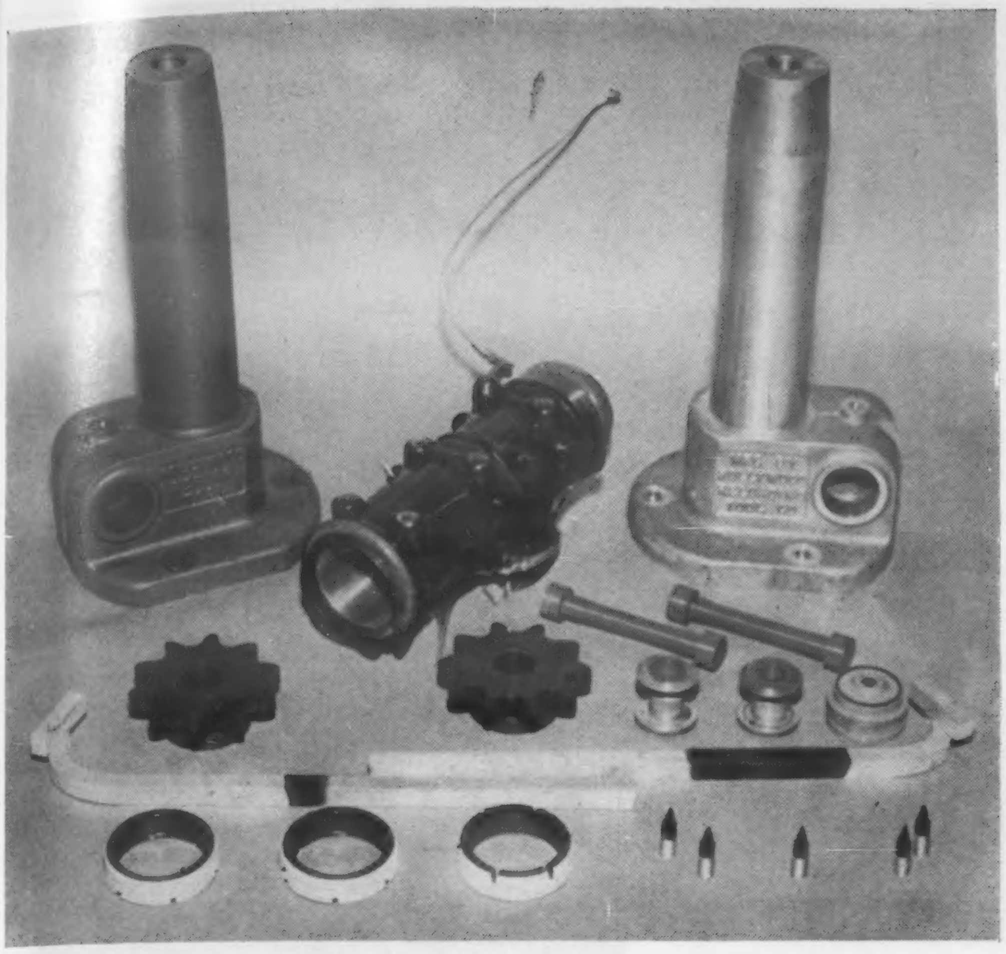
Fast electrolytic process gives abrasion-resistant, corrosion-resistant surface.

■ A NEW PROCESS for "hard anodizing" of aluminum promises to further broaden the wear, corrosion and electrical applications for that metal.

The process was developed by Sanford Process Co., Inc., Los Angeles, and is similar in operation to other hard anodizing processes, except that a thick oxide coating can be obtained in an exceptionally short time. For example, a 6-mil coating can be obtained in only 55 min instead of about 4 hr as required by the MHC process (*see M&M, Aug., 1950, pp. 62-4*). Still thicker coatings can be obtained.

Consequently, the process seems particularly adapted to parts where abrasion-resistant, corrosion-resistant or dielectric coatings thicker than the standard 2-mil "hard coat" are desired. Current wear applications include pistons, valves, cams, abrasion strips, friction bearings, brake disks and computer gears. Corrosion applications include parts for boats and seaplanes. Dielectric applications include coil forms where integral insulation is desired to reduce weight and minimize the possibility of damage. Another important field of application is overmachined or worn parts too expensive to be scrapped and replaced.

In general, the heavy aluminum oxide coatings produced by the Sanford process enable lightweight aluminum to be used where other metals, more wear-resistant or more corrosion-resistant than aluminum, were formerly required. Heavy oxide coatings are cheaper than hard chromium coatings and are considered to be competitive with the hard nickel-phosphorous coatings obtained from the electroless nickel plating process. Oxide coatings are not suitable where electrical conductivity is



These parts *were wholly or partially treated by the Sanford process.*

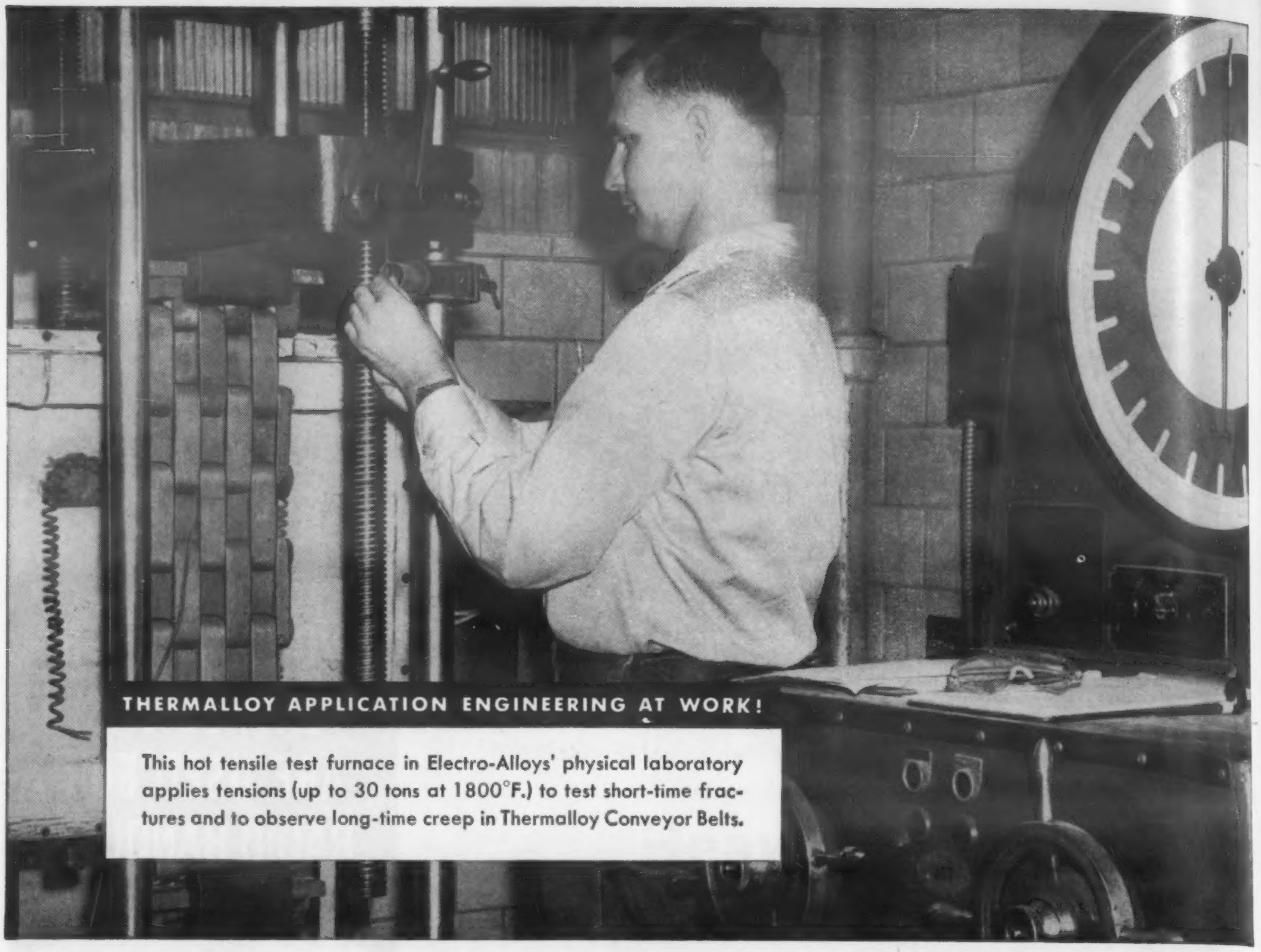
for Aluminum

by Thomas A. Dickinson

required. However, surfaces that are inaccessible to electroplating are readily coated by anodizing, and oxide coatings are also advantageous where short-time heat or flame resistance is desired. At present, Sanford-treated aluminum parts are replacing other metals in household appliances, cookware, lawn furniture, theater escape locks, gas and water meters, and machine tools.

The Sanford oxide coatings have a measured Rockwell hardness ranging from C50 to C58, a Mohs scratch hardness of about 8, and slightly more abrasion resistance than case-hardened steel. Thick coatings can withstand up to 4000 v. The color of the resulting coating depends on its thickness and on the alloy treated. For example, a thin coating on 75S, 61S or 24S is amber. Heavier coatings may be brown, black or gray-black on 75S; light or dark black on 61S; and light or dark blue on 24S.

Like other hard anodizing processes, the Sanford process utilizes a cold acid electrolyte and progressively increasing voltages. The exact nature of the Sanford electrolyte has not been disclosed, although it contains both mineral and organic acids. (Other processes utilize either sulfuric acid or a combination of sulfuric and oxalic acids). Bath temperature ranges from 0 to 15 F—considerably lower than in other processes. Voltage ranges from 15 to as high as 150 d.c. and current density is 12-15 amp per sq ft. The normal sequence of operations is: vapor degreasing, masking if required, immersion in the electrolytic bath for a controlled time, and cold water rinse. If no organic coating is to be applied, the oxide coating is then sealed by a 1-hr hot water immersion.

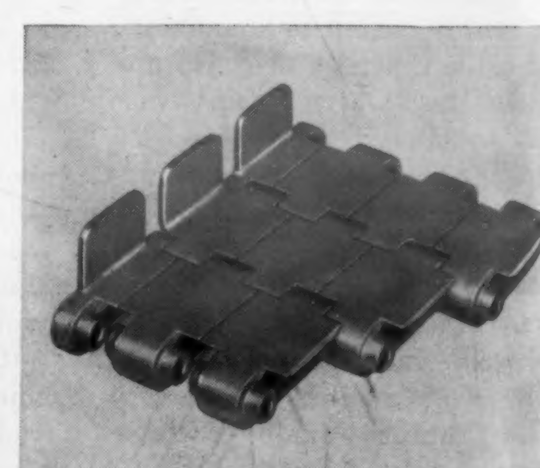


A miniature furnace to test theories!

Service life of a heat-treating furnace conveyor belt may be affected by so many variables, i.e. uneven loading, misalignment, temperature differentials, etc., that proper design, highest quality and the right material are of utmost importance.

At Electro-Alloys, a staff of engineers and metallurgists are constantly studying these factors in the physical testing laboratory shown above. A hot tensile test furnace is continually in use subjecting Thermalloy* conveyor belts to various combinations of loading and temperature. In this way, design theories developed by our engineers are tested and highest possible quality standards are maintained to insure production of furnace conveyor belts that will be the ultimate in trouble-free operation.

Electro-Alloys also applies engineering and metallurgical know-how in the production of heat-resistant Thermalloy castings for other furnace parts such as sprockets, idlers, skid rails or rollers, crossbeams, wall boxes and radiant tube assemblies. For complete information, call our nearest representative or write for Thermalloy Conveyor Belt Bulletin T-241, Electro-Alloys Division, 6001 Taylor St., Elyria, Ohio.



To meet extra-severe operating conditions, a Thermalloy Heavy-Duty Conveyor Belt was developed. This partially assembled belt shows the short integral cast pins that eliminate "crank-shafting."

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION

Elyria, Ohio

*Reg. U. S. Pat. Off.

For more information, turn to Reader Service Card, Circle No. 398

New Materials, Parts and Finishes
and related equipment

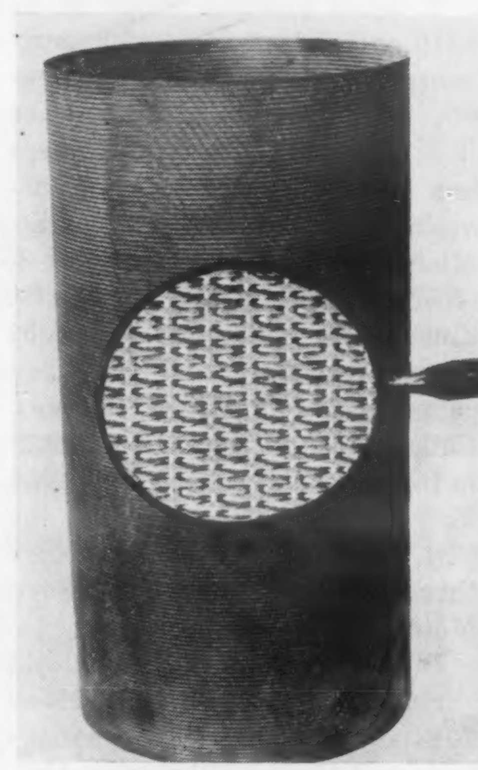
New Porous Sheet Material for High Temperature Use

A new porous material called Rigimesh has been developed which possesses high strength coupled with controlled porosity. Developed by *Aircraft Porous Media, Inc.*, Glen Cove, N. Y., the sheet is made by welding together the warp and woof strands of one or more layers of woven wire cloth, then mechanically treating it to produce a homogeneous plate which has fine openings but retains the uniformity of the original material. Metals used include all alloys which can be drawn in the form of wire. For moderate temperature service, types 304 and 316 stainless steel are available. Alloys such as L-605 will be stocked for higher temperature applications.

Flow capacity for coolant gases and liquids may be varied from 15 ft per sec (900 cu ft/min/sq ft) at 1 psi differential pressure, down to 0.2 ft per sec at 1 psi. According to the manufacturers, a high degree of uniformity of flow can be obtained. Also flow capacity from point to point can be altered in a controlled manner.

Strengths of the material are said to generally exceed equivalent strengths of comparable materials. Room temperature tensile strengths for some grades are said to exceed 60,000 psi. To obtain the degree of heat transfer required, thickness may be varied from 0.005 to 0.125 in., and heat transfer coefficients may be increased further by using finer wire.

The material can be readily formed, and most grades are ductile enough to be formed into a sharp 180-deg bend. Also directional properties are available to assist in weight reductions where design permits.



Magnified segment *shows texture of new woven wire porous sheet.*

New Insulating Varnishes Meet MIL Specs

Three new air-drying varnishes and a baking varnish have been developed to meet MIL-V-1137A and -173A specifications for insulating electrical equipment and components. They are being marketed by the *Insl-X Sales Co.*, 26 Rittenhouse Place, Ardmore, Penna.

Insl-X P-83 and P-84 are said to meet the performance specifications of MIL-V-1137A, and are clear impregnating varnishes formulated from synthetic resins and blended with modifying oils to produce high dielectric strength films which are oil- and water-proof. P-83 is a general purpose baking varnish which is said to penetrate and build well, effecting good bonds between conductors. P-84 is an air-dry varnish which is recommended for shallow wound coils and as a water-proof finishing varnish. Recommended applications for the two materials include impregnation of small coils, armatures, automotive generators, glass or nylon covered wire, and for general motor usage.

Insl-X P173 is an air-dry varnish formulated with phenolic resin and tung oil, and is available in two variations to meet specifications of MIL-V-173A Types I and II. The new compounds are recommended for use in tropical conditions as fungus- and moisture-resistant coatings for electronic and electrical equipment. According to the manufacturers, the coatings provide good adhesion, high dielectric strength, resistance to thermal shock and low water-vapor permeability.

(More New Materials on page 136)

New Materials, Parts and Finishes

and related equipment

Impregnated Wood

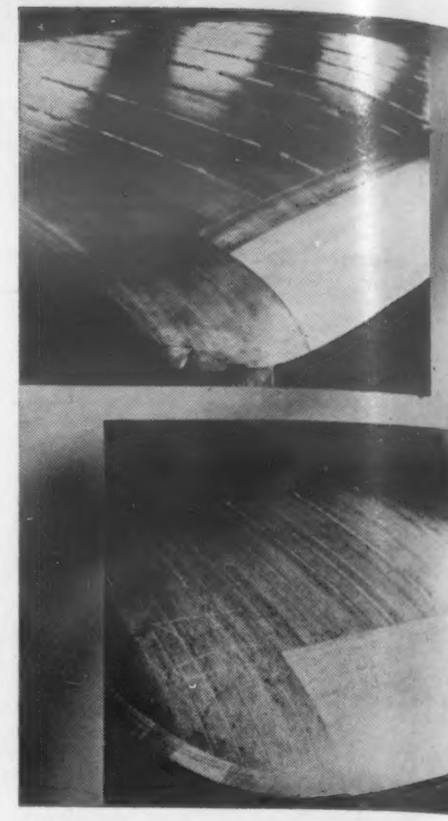
Has Improved Dimensional Stability

A wood product made up of 1/10 or 1/16-in. solid mahogany veneers impregnated with phenolic resins and bonded together in ¾, 1 and 1½ in. thicknesses has been marketed by the *Haskelite Mfg. Corp.*, Grand Rapids, Mich. The process provides a wood product which will resist dimensional changes brought about by swelling and shrinkage caused by humidity changes. Called Hasko-Preg, the product is the result of work done by the Forest Products Lab., of the U.S. Department of Agriculture through a grant from the Ford Motor Co.

In Hasko-Preg, swelling and shrinkage is reduced as much as 70% over that of solid mahogany, and the equilibrium moisture content is permanently reduced. As a result the material is only slightly affected by the length of time of exposure to humidity conditions. Its hardness and compressive strength are slightly increased, and its resistance to decay is greatly increased because of the reduction in moisture content which supports decay. Limited tests have indicated that the material has good resistance to marine borer attack, and the reduced equilibrium moisture content increases the electrical resistivity.

Hasko-Preg has good resistance to acids and heat. No significant charring or disintegration was found until temperatures of 525 to 550 F were reached. Thermal cycling from room temperature to 400 F was carried out 80 times with no apparent disintegration.

The material is suited to die model and pattern work, particularly on parts that require several months to complete or where storage is necessary. In some cases where solid mahogany is used, distortion due to shrinkage and warpage is so great that after completion of the model or pattern the entire shape must be reworked.



Conventional *solid mahogany (top) and impregnated mahogany (bottom) were used in these two die patterns. After exposure to high relative humidity for 30 days, the warping and stretching of conventional mahogany is evident.*

The material is available in random widths from 4 to 20 in., and lengths up to 96 in. The sections may be bonded together in any thicknesses by the use of resorcinal or epoxy type adhesives.

Fluorocarbon Polymer in Granular, Powder or Dispersion Form

Polyfluoron, a high molecular weight thermoplastic polymer of chlorotrifluoroethylene, is being supplied by the *Acme Resin Corp.* to the *D & R Pilot Plants, Inc.*, Hazardville, Conn., who are handling eastern and sales engineering service for the material. The polymer is available as crystal granules, or low density and micro-atomized powder, as well as in a 40%-solids dispersion. Three grades with varying molecular weights are being produced. It can be formed by conventional thermoplastic molding and extruding processes.

The material resists temperatures up to 400 F and is unaffected by strong caustics, acids and oxidizing agents such as fuming nitric acid and aqua regia. It is also said to have good resistivity and power factor values at high temperatures and no water absorption. Dimensional stability is maintained over a temperature range of —330 to 374 F.

Polyfluoron is particularly recommended for use in electronic wire insulation for elevated temperature service, radio tube sockets, printed circuits, valve seats, diaphragms and gaskets. The dispersion system for electrical and corrosion barrier coating applications would indicate use of the material in the chemical processing, electric power, electronic and packaging industries.

Electrical Aluminum Combines Strength and Conductivity

A new aluminum bus conductor material has been developed to combine strength and electrical conductivity to aid the electrical industry expand its use of aluminum. A primary objective in the development of a new electric bus conductor material is to provide bus with the same strength as copper in the direction of short-circuit forces. When replacing copper bus with aluminum, it is advantageous to increase the width of the bus rather than the thickness to compensate for the difference in current-carrying capacity. This provides much larger surface area for dissipation of heat, resulting in more efficient use of the aluminum.

Developed by *Reynolds Metals Co.*, 2500 S. Third St., Louisville, Ky., RABC alloy provides a guaranteed minimum tensile strength of 29,000 psi with a guaranteed minimum 55% conductivity (IACS). Short-circuit strength varies directly with tensile strength and width. By calculations taking into account the minimum tensile strength of copper bus bars, it can be seen that a 1/4 x 4 in. bar of RABC can replace a 1/4 x 3-in. copper bus where short-circuit forces are a factor with no change in spacing of supports while maintaining maximum heat dissipation.

The new alloy meets the flatwise bending requirements for EC bus bar as it will withstand bends of 90 deg around a mandrel having a radius equal to the thickness of the bar. An accompanying table lists properties of the new alloy in comparison with those of EC-H17 and copper. An additional table presents a cost comparison showing the cost advantage, which is the major purpose in selecting aluminum rather than copper for bus conductors.

COST COMPARISON

	Copper	Aluminum	
		EC-H17	RABC
Wt per ft, lb	2.9	1.17	1.17
Price per lb	$0.45	$0.607	$0.426
Price per ft	$1.30	$0.71	$0.50

COMPARISON OF PROPERTIES OF SOME BUS CONDUCTOR MATERIALS

	Copper	Aluminum	
		EC-H17	RABC
Ten Str, psi	33,000–37,500	17,000	29,000[a]
Yld Str, psi	Not specified	15,000	25,000[a]
Elect Cond, % IACS	93%	61%	55%[a]
Current Carrying Capacity[b]	100%	82%	79%
Resistivity at 20°C, microhms, sq in./ft	8.31	13.36	14.82
Mod of Elast, psi.	16 x 10^6	10 x 10^6	10 x 10^6
Density, lb/cu in.	0.322	0.09765	0.09765
Temp Coef of Resist, %/°C at 20°C	0.393	0.403	0.360

a Guaranteed minimum.
b For given temperature rise and same cross section

New Steel Has High Hardness and Impact Resistance

A new alloy steel with a tensile strength exceeding 220,000 psi, a yield point exceeding 180,000 psi, a Brinell hardness of 470 to 520 as supplied and possessing Charpy impact values of around 20 ft-lb has been developed by *American Steel Foundries*, E. Chicago, Ind. These properties are said to be retained at operating temperatures from —50 to 450 F. Called Wearpact, the steel has been undergoing field testing in taconite, hematite and copper mining operations. The initial hardness is retained in sections up to 6 in. thick, with a slight reduction in hardness of thicker sections.

According to the producer, Wearpact can be welded by conventional arc-welding methods, its hardness being affected only in the immediate weld area. It can be machined on heavy equipment or finished by grinding. No difficulty has been experienced in casting the steel and shrinkage rates are comparable with those of most cast steels.

The steel is said to be suitable for applications such as chute and crusher liners, dipper teeth and other applications where hardness and impact resistance are critical service requirements.

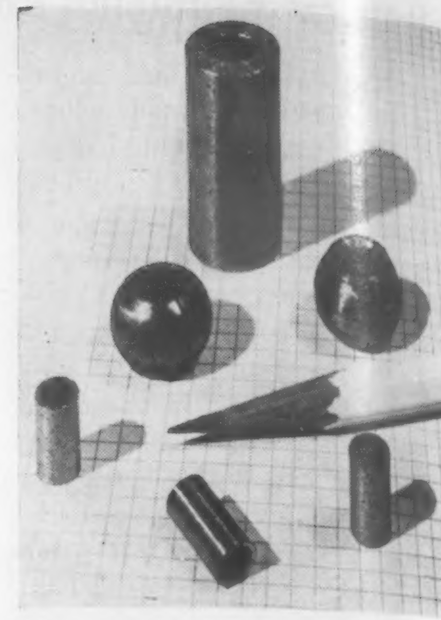
(More New Materials on page 138)

New Materials, Parts and Finishes

and related equipment

Solid Lubricant For Wide Temperature Range

A solid lubricating material, said to operate at temperatures from −120 to 500 F, has been marketed by *Booker-Cooper, Inc.*, 6940 Farmdale Ave., N. Hollywood, Calif. The material can be used with or without oil as a bearing material, and is said to offer high wear resistance. According to the producer, the material contains over 40% lubricative solids and has an ultimate compression strength of 22,700 psi. When used with oil it has good retention and absorption qualities which provide a wicking action to supply bearing surfaces with a lubricative film.



New solid lubricant *can be used as bearings with oil or without.*

New Glass Resists Electrical, Thermal Shock

A new type of glass for use in hermetically sealed electrical feed-through terminals is said to be rated at 100,000 megohms insulation resistance at 300 F. It is also said to have improved flash-over. Designated V-24 by the *Fusite Corp.*, 600 Fernview Ave., Cincinnati 13, Ohio, the glass is available in all standard models and electrodes made by the company. The company claims the new glass will withstand heavy abuse and remain leak-proof.

In conjunction with the new glass, an alloy pin has been developed which, combined with a mild steel cap and V-24 glass, has a high degree of corrosion resistance.

Two New High-Impact Polystyrenes

Two new rubber-modified polystyrenes, one a high-impact the other an extra high-impact material, are now available in commercial quantities from *Bakelite Co.*, a Div. of Union Carbide and Carbon Corp., 30 E. 42nd St., New York 17. High-impact polystyrene TMD-5151 and extra high-impact polystyrene TMD-2155 combine superior physical toughness with moldability.

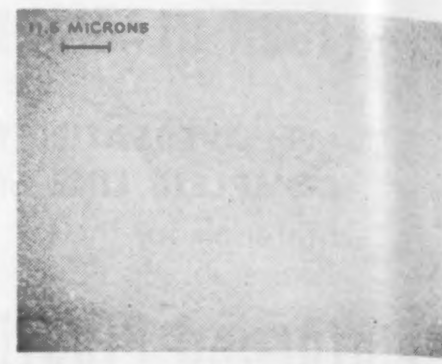
Both materials are said to be readily moldable and to possess fast set-up, uniformity, good finish and are available in a wide range of opaque colors. Applications for the materials include structural parts for refrigerators, toys, plastics pipe fittings and other uses where extra toughness is a requirement.

AVERAGE PHYSICAL PROPERTIES

	ASTM Spec.	2155	5151
Izod Imp Str, ft-lb/in. of notch	D256-47T	—	—
1/8-in. bar at 73 F	—	8	3.5
at 32 F	—	4	2.0
at −13 F	—	0.9	0.7
1/4-in. bar at 73 F	—	4.5	1.0
Ten Str, psi	D638-49T	4500	4300
Elong in Ten, %	D638-49T	25	30
Flex Str, psi	D790-49T	No Failure	No Failure
Flex Mod, psi	D790-49T	275,000	375,000
Heat Distortion Temp, 1/4-in. thick, 264 psi, F	D648-45T	184	176
Therm Coef of Lin Exp, per °C	D696-45T	$6.5\text{–}8.5 \times 10^{-5}$	$6.5\text{–}8.5 \times 10^{-5}$
Water Absorp, % gain in wt	D570-50	−60	0.10
Rockwell Hardness, M	D785-48T	25	15
L	—	—	70
Dielectric Str v/mil	D149-44	—	—
Short Time	—	515	460
Step by Step	—	485	464
Vol Resist, megohms-cm	D257-49T	$>3 \times 10^7$	$>3 \times 10^7$
Surface Resist, megohms	D257-49T	$>5.4 \times 10^5$	$>5 \times 10^5$

(More New Materials on page 140)

New Materials, Parts, Finishes



Average particle size *in new mold release agent is less than 0.5 microns, or about 1/10 that of . . .*

average particle size of other comparable silicone release emulsions.

Parting Agent Frees Rubber, Plastics and Metal

Said to be more resistant to creaming or separation than other comparable silicone emulsions, Mold Release Emulsion 36 has been developed for use with rubber, plastics and metals. Produced by the *Dow Corning Corp.*, Midland, Mich., the material is said to be unaffected by additives or common metals, creams slightly after standing 3 days in a 100 to 1 dilution and does not deposit out on tank walls. It is dilutable in hard or soft water and imparts a smooth glossy surface finish to molded rubber parts. The latter attribute is said to be partially due to its small particle size — approximately 1/10 that of earlier silicone emulsions.

Company tests to date indicate

• **For more information, turn to Reader Service Card, Circle No. 302**

New Materials, Parts, Finishes

that the 36 Emulsion will not break after 168 hr at 158 F, or after 8 freezing and thawing cycles, or after recirculation through a centrifugal pump. After 30 min in a high speed centrifuge, it separates less than 2% and can be reconsolidated by gentle agitation. It is said to be priced in the same range as other silicone release agents and is available in commercial quantities.

Plastics Pipe Has High Rigidity, Impact Strength

Intended primarily for use in industrial and chemical plants, a new thermoplastic Koroseal pipe has been marketed which is said to have high impact strength and rigidity. Produced by the *B. F. Goodrich Co., Industrial Products Div.*, Akron, Ohio, the new pipe is said to have been made possible by a new method which permits extrusion and molding of rigid, high impact products.

The pipe is chemically resistant, odorless, will not rot or corrode, and has good aging properties for indoor, outdoor and underground use. The pipe is available in lengths up to 20 ft and diameters from ½ to 2 in. It is furnished with threaded fittings for ease of assembly and disassembly.

Rigid Koroseal pipe is gray in color and may be painted with vinyl base paints. It can be bent by heating to 250 to 300 F. Flanged connections are recommended for joining the pipe to other pipe systems. Threaded joints can be chemically joined or heat-welded for permanent installations.

(More New Materials on page 144)

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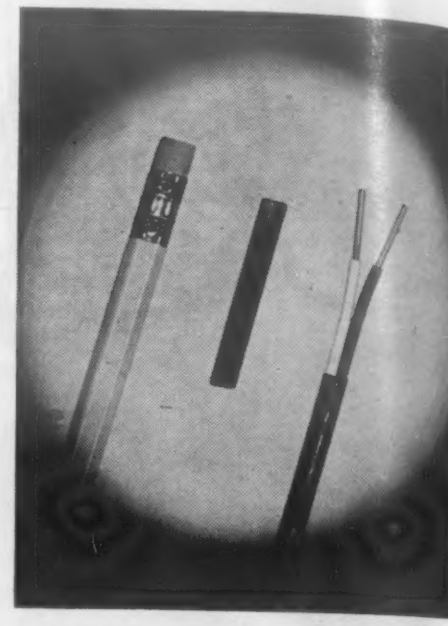


Nylon Protects Thermocouple Wire

The use of nylon over polyvinyl insulation on a new thermocouple extension wire is said to provide wire with smaller diameters; smoother surfaces; increased resistance to flame, moisture, petroleum products and fungus; simplified stripping; and lower cost. The wire, type PN, is produced by the *Thermo Electric Co., Inc.*, Saddle River Township, Rochelle Park, P.O., N. J. It is made for iron constantan, copper constantan and chromel alumel wires in 14, 16, and 20 gage.

Size of Reinforced Polyester Sheet Increased

The available size of sheets of Lamicor, a glass fiber-reinforced polyester material has been increased to 51 x 105 in. in any desired thickness, according to *Strick Plastics Co.*, 31-06 38th Ave., Long Island City 1, N. Y. Similar to other glass-reinforced polyester sheet, the material is said to be impervious to acids, gasoline and petroleum products up to temperatures of around 200 F. It is non-porous and is available in a variety of colors. It ranges in degree of light

New Materials, Parts, Finishes

transmission from 50% translucent to completely opaque.

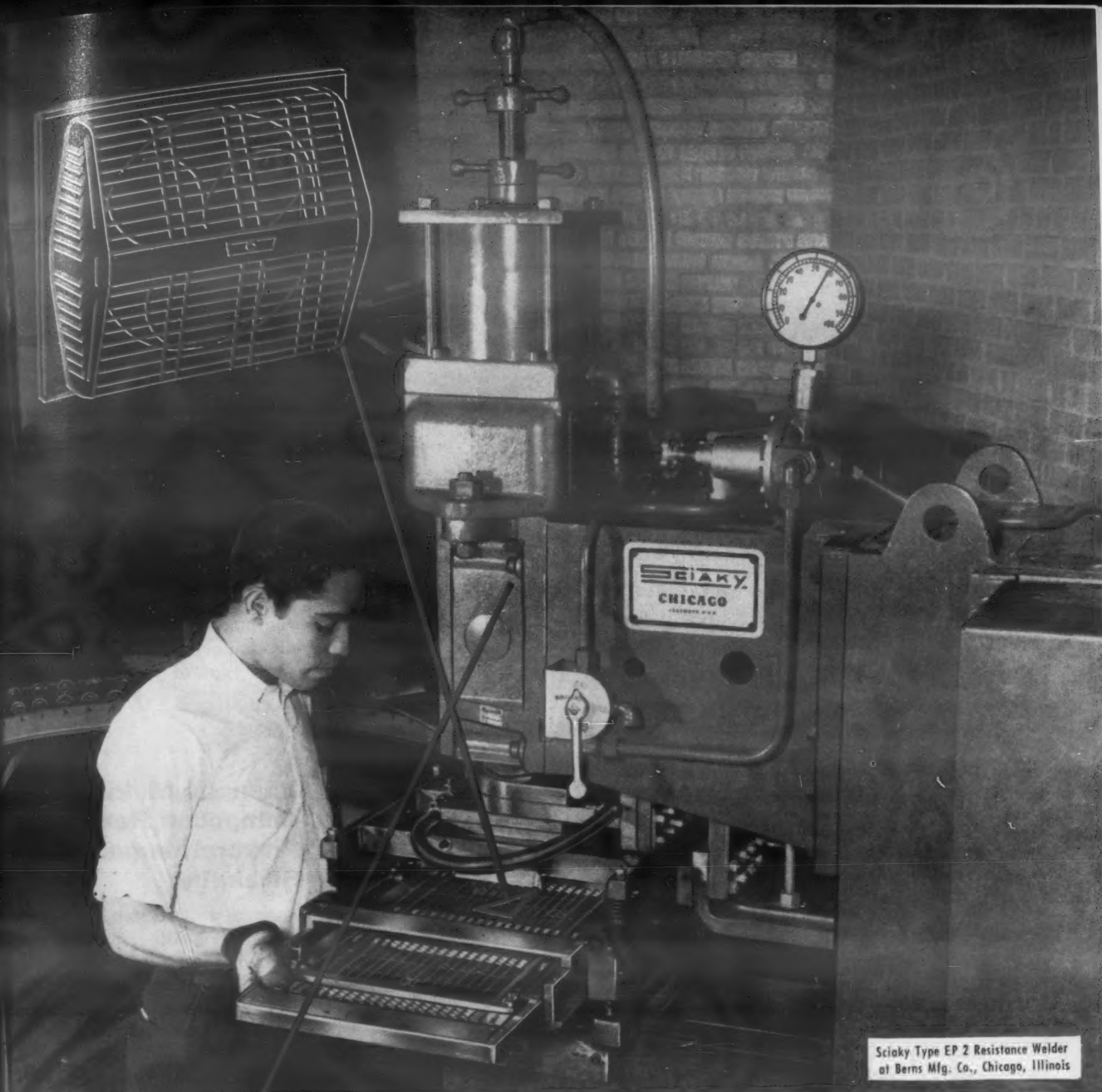
Lamicor will not corrode, rot or mildew and is unaffected by fungi, vermin or termites, according to the manufacturers. It is said to be a good electrical insulator and has a power factor of 0.03 at 60 cycles; 0.01 at 1 megacycle. It also has a high arc resistance. As well as structural uses, the manufacturers recommend the material for use as punched terminal boards, insulators, switch plates, and other similar component applications in motor generators, transformers, switch gears, radio and television.

Silicone-Aluminum High Temperature Paint

Silicone and atomized silver aluminum have been combined in a rust and corrosion resistant paint, said to resist temperatures up to 1600 F. Called Sili-Kool, the material has been developed by the *C. H. Cragert Co.*, P.O. Box 5092, Dallas, Tex. According to the producers, one coat of the paint will protect for more than a year, stacks, boilers, steam pipes, diesel and gas engines, exhausts, manifolds and mufflers at high temperatures and during exposures to severe climatic conditions.

Resistance Heating Speeds Tube Welding of Various Metals

A new method whereby special contacts heat the edge of the metal strip by r.f. current has been developed which is said to speed and simplify the welding of tubing in aluminum, steel, stainless steel, copper and brass. Developed by the *New Rochelle Tool Corp.*, 320 Main St., New Ro-



Sciaky Type EP 2 Resistance Welder at Berns Mfg. Co., Chicago, Illinois

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rite for complete specifica-
ons showing minimum to
aximum welding capacities
r the standard Sciaky Type
EP 2 Projection Weld-
er contained in
Bulletin 317-2.

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With one welder Berns was producing only one-quarter the needed production of 29 piece, 10 gauge wire grills for their nationally known Air King Fan. Instead of selling three more machines, Sciaky provided the newly designed, standard EP 2 Welder equipped with simple tooling to replace the original machine. Production jumped 420% as one machine does the work of four plus, the customer has the original welder for other work.

Write for the complete details of Berns' impressive production increase and equipment savings as well as other similar examples of single welder applications contained in "Resistance Welding at Work", Vol. 4, No. 1.

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New Materials, Parts, Finishes

chelle, N. Y., and using high frequency power, the process is said to be capable of speeds up to 300 ft per min, and can be used on conventional tube mills. The speed is independent of the tubing diameter and the equipment operates on all metals and diameters interchangeably. The equipment causes pin-point heating so that only the immediate weld area is affected. According to the manufacturers, the process requires lower power equipment at lower cost than induction or other methods for the same type of production.

Phenolic Molding Compound Has High Flexural, Impact Strength

A new two-step, cord-filled phenolic molding material has been marketed with a minimum flexural strength of 18,000 psi and a minimum Izod impact strength of 14 ft-lb per in. of notch. Developed by the *Fiberite Corp.*, Winona, Minn., and designated FM 11679 Black, the material has a plasticity that is said to be medium to hard, a heat resistance up to 250 F for molded parts and a compressive strength of 18,000 psi.

Liquid Catalyst Boosts Heat Resistance of Epoxies

A new liquid curing agent for epoxy resins has been developed which is said to ensure the retention of physical properties of castings, laminates, adhesives and structural members after exposure to temperatures up to 300 F. Since it is in liquid

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form, Curing Agent 105 requires no premelting or preheating and provides longer pot life and lower exotherm temperatures during curing. As a result of the lower exotherm, thicker sections of resin can be cured without cracking or distortion, according to the producers, *Aries Laboratories, Inc.*, 270 Park Ave., New York 17. Heretofore, reduction in exotherm has been produced mainly by using various filler materials. Materials cured with Curing Agent 105 are said to possess high electrical properties up to the heat distortion point.

Polyethylene Adhesive

A new plastics adhesive called Polygriptex has been developed primarily for bonding paper labels to polyethylene containers. Produced by the *Adhesive Products Corp.*, 1660 Boone Ave., New York 60, it is expected to provide simpler and more economical packaging operations when using polyethylene containers. It can be applied by conventional labeling machines.

Contents Noted

A digest of papers, articles, reports and books of current interest to those in the materials field.

This Month:

- *Ductility of chromium*
- *New tests for varnish coatings*
- *Laminating vinyl materials*
- *Replacement for tin bronzes*
- *Thickness gage for plated coatings*

Altering Sintering Mechanisms Improve Powder Metal Compacts

Recent work in powder metallurgy indicates that the sintering of compacts can be accelerated and better physical properties obtained by various alterations of the sintering techniques. The mobility of atoms on the surface layers of the solid particles would seem to have a direct effect on these factors. Of fifty papers presented at a Symposium on Powder Metallurgy in London last December, three dealt directly with this aspect, discussing methods of accelerating the sintering reactions in compacts.

Activated sintering

The term "activated sintering" was used by M. Eudier in describing a new process developed in France which produces compacts of comparatively low density and unusually high elongation values after sintering for only short periods. The process makes use of an atmosphere containing a hydrogen halide at the start of the sintering process. Salts are formed on the surfaces of the metal particles. Upon heating the compact to a temperature at which the salt becomes molten, the liquid tends to gather at the sharp corners of the pores, rounding off the pore cavities. By changing the furnace atmosphere, the salts may then be decomposed and the metal atoms agglomerate while the pores retain their rounded form. Thus, rounded pores are produced without increasing shrinkage, and this rounding eliminates the notch effects caused by irregularly shaped pores.

According to the author, the process may be carried out by placing the green compacts in a box with a lid sealed in position with alumina cement. A small quantity of a suitable salt is introduced with the compacts. One example cited is the use of ammonium fluoride in the sintering of iron compacts. At 480 F this salt decomposes and the resulting hydrogen fluoride forms a film of iron fluoride on the surface of the iron particles. Over a period of time the iron fluoride, which melts at 1900 F, is decomposed by the hydrogen in the furnace atmosphere and slowly diffuses out of the box. M. Eudier quotes figures showing that an elongation of over 10% at fracture can be obtained in an iron compact with a density of 5.7. Also, test pieces can be twisted cold through several complete turns without fracture.

The reactions involved are believed to occur on a cyclic basis. The reaction products form gaseous currents which facilitate the exchange of atoms between different points on the surfaces of the pores. The theory of the cyclic process is based on the fact that only 2 gm of ammonium fluoride or chloride are sufficient to produce activated sintering in a box 1 cu decimeter in volume, containing 2 kg of compacts. This amount of halide would be sufficient to produce only a mono-molecular layer of iron fluoride on the surface, which would be insufficient to bring about the observed results.

Effect of molybdenum disulfide on stainless steel

In another paper, B. Sugarman discussed the effects of the addition of small amounts of molybdenum disulfide on the sintering of 18:8 stainless steel compacts. The molybdenum disulfide was added as a minus 300-mesh powder, replacing an equivalent amount of minus 300-mesh metal powder. Results showed that the porosity of the compact was considerably reduced and the ultimate tensile strength was improved. The ultimate tensile strength increased rapidly with increase in compacting pressure, rising from 54,000 psi at 60,000 psi compacting pressure to 76,000 psi at 100,000 psi compacting pressure. The grain size of the modified compact was shown to be considerably smaller than that of the unmodified material.

The author suggests no explanation for the mechanism which causes the improvement of properties. However, two factors may be the cause: the molybdenum disulfide may melt, causing rounding of the pores as indicated by Eudier, or the decomposition of the molybdenum disulfide may provide molybdenum atoms with a high degree of mobility, as is the case with compacts made from zirconium hydride discussed below.

Zirconium compacts from hydrides

In a paper discussing grain growth during sintering, Dr. H. H. Hausner showed that the most convenient method for making zirconium powders is by producing them from hydrides. Hydrides form in the range of 450 to 1470 F and decompose to

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metal under vacuum at temperatures above 1470 F. The hydrides pulverize more readily than the metal itself so that very fine particles of metal can be produced by the decomposition of hydrides. Hydrides can be compacted easily and sintered to full density at temperatures as low as 2100 F, whereas compacts made from metal powder do not densify completely below 2450 F.

The author suggests that during decompositon of the hydride, the zirconium atoms become more mobile causing a higher rate of sintering and faster disappearance of the voids than is the case in compacts made from the metal.

Ductility of Chromium at Room Temperature

Although previous work has indicated that chromium is invariably brittle at room temperature, results of a recent study show that it is possible to produce chromium capable of at least 15% elongation in a room temperature tensile test. The brittleness of the material at room temperature seems to be caused by an impurity. In a paper published in the December issue of the *Journal of The Institute of Metals* last year, H. L. Wain, F. Henderson and S. T. M. Johnstone, all of the Aeronautical Research Lab. of the Dept. of Supply, Melbourne, described work carried out to determine the cause of room-temperature brittleness and some of the factors governing ductility of chromium at room temperature.

Results summarized

The authors found that chromium could be produced with sufficient ductility in tension and bending at room temperature to indicate that the production of ductile chromium-base alloys for high temperature use is a definite possibility. Testing by heating chromium in air, oxygen and nitrogen showed that small amounts of nitrogen, apparently

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present in solid solution, produced room-temperature brittleness. This embrittlement occurs upon heating in air or nitrogen at as low as 1200 F. Ductility does not appear to be affected by heating in oxygen.

The authors found chromium to be notch-sensitive, and surface notches produced by filing or coarse grinding can seriously reduce ductility. Light etching or fine polishing can normally remove this effect. Recrystallized chromium can be rendered ductile at room temperature, but is more susceptible to embrittlement by air or nitrogen than is the cold-worked chromium. For example, a nitrogen content of approximately 0.02% by weight produces brittleness in the cold-worked material, while 0.001% by weight appears to be effective in embrittling recrystallized chromium. Ductility can usually be achieved in recrystallized chromium by electropolishing.

The work described in the paper definitely confirms the temperature-dependence of brittleness in chromium. The authors also include a hypothesis, based on Cottrell locking effects, to explain their observations, and an appendix by E. J. Lumley describes analytical methods for determining nitrogen and oxygen in chromium.

Need Stressed for New Tests for Varnish Coatings

The thermal stability of electrical insulating varnishes is usually tested by evaluating the effect of elevated temperatures on the physical and electrical properties of a varnish film sample. According to A. H. Haroldson of the Continental Diamond Fibre Co., the results of present test methods are insufficient for properly evaluating thermal deterioration of the films. They are useful for control and classification purposes, but according to Mr. Haroldson

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they do not duplicate service conditions.

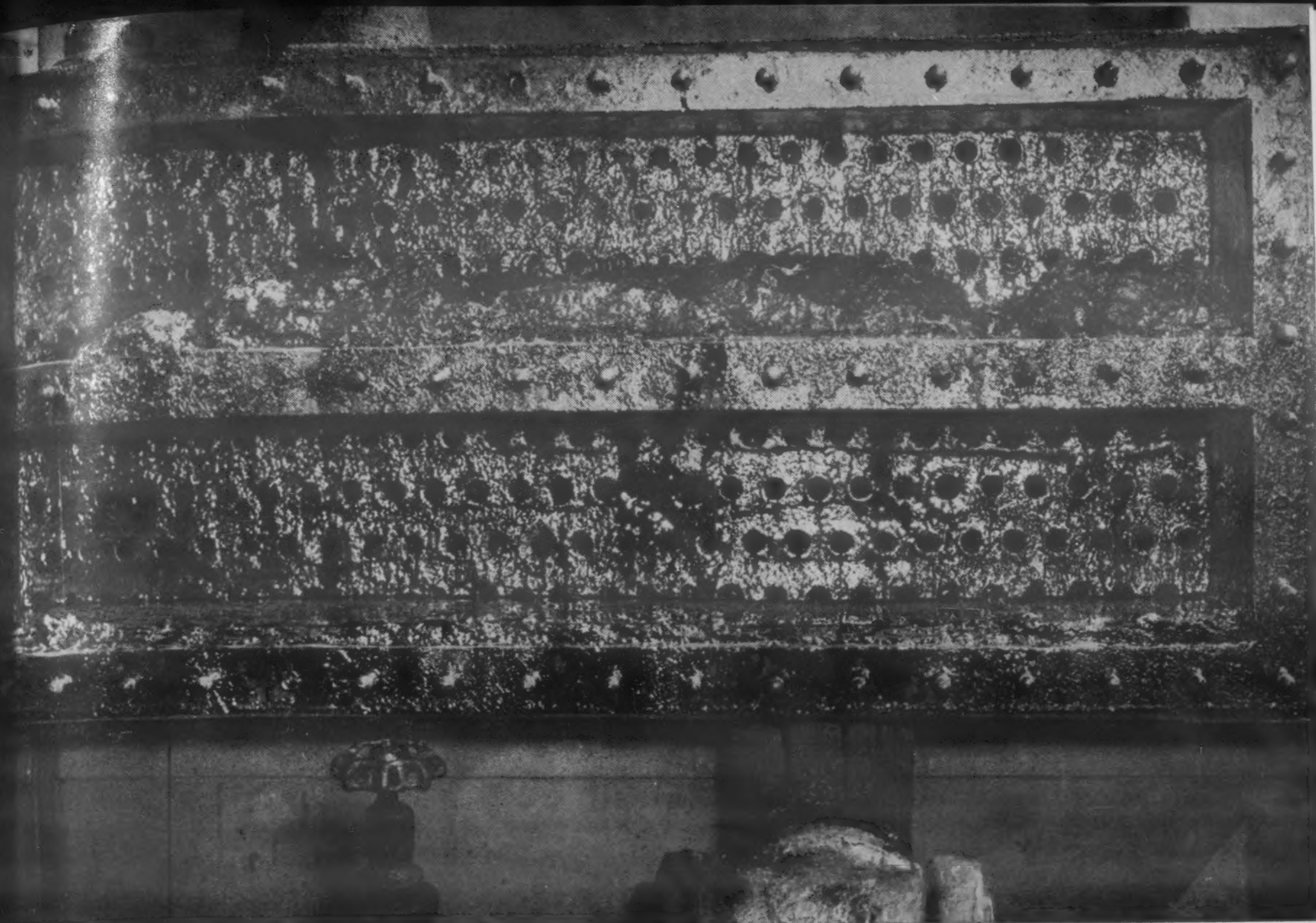
In a paper published by the American Society for Testing Materials, Mr. Haroldson points out that too great a reliance should not be placed on short-time tests alone, but they should be supplemented by long-time tests. The dielectric strength test can be used for evaluating deterioration of varnish films due to heat aging. Crazing during heat aging is a definite indication of deterioration and will result in a lowering of the dielectric strength.

The formation of cracks in a varnish film when it is bent 180 deg around a 1/8-in. mandrel does not necessarily indicate thermal deterioration, since many of the varnishes contain phenolic resin forming hard brittle films which will resist thermal breakdown, but will not withstand the bend test. The mandrel bend test is useful for determining the rate of embrittlement of varnish film due to heat aging.

The author stresses the need for new tests for determining thermal deterioration of varnish films which will be capable of predicting film performance under actual service conditions.

Laminating Vinyl Materials

Laminating vinyl materials simply entails raising the temperature of the sheets above the point of fusion (about 350 F), joining two or more layers of the heated vinyl with enough pressure to eliminate all bridges and voids, and allowing the laminate to cool. This process should provide a solid, inseparable laminate. However, there are several practical problems involved in the commercial production of high quality vinyl laminates which complicate this seemingly simple procedure. These factors were pointed out by Vernon Pierce of Kaykor Industries in an address before the Fifth



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Plastics Film, Sheeting and Coated Fabrics Div. Conference of the Society of The Plastics Industries, Inc., in December last year. Mr. Pierce discussed four basic commercial methods of laminating vinyls and the advantages and disadvantages of each.

Laminating at the calender

The first method, laminating at the calender, came into prominence when some difficulty was experienced with pinholes in inflatable toys. Pinholes were caused by small particles of foreign matter imbedded in the vinyl sheet. When the sheet was stretched and inflated, the particle was forced out, leaving a pinhole. By calendering a 6-mil sheet and introducing it between the middle and bottom roll of a calender producing another 6-mil sheet, a 12-mil laminate resulted, which in all probability would not have coincident impurities in each of the sheets. With the recent improvement in materials, testing and housekeeping conditions in the industry single-pass vinyl sheeting has received more and more acceptance due to reduction in pinhole problems, so that only about 3 to 5% of the inflatable material used today is produced by laminating at the calender.

A variation of this method is used by the upholstery and automotive industries which get approximately 50% of their supported vinyl material from laminating cloth to vinyl at the calender. The cloth first receives an anchor coat of vinyl, and is heated just before the cloth enters the calender rolls which carry the softened vinyl film. The process provides the advantages of a good bond, economical lamination on large runs, and less heat history on the vinyl material. On the other hand, small runs are difficult and thicknesses of 8 to 10 mils of vinyl are the minimum which can be produced.

Post-laminating film and cloth

The second method discussed involves laminating a calendered

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film and an anchor coated cloth between a rubber roll and a steel cylinder controlled by adjustable air pressure. As the rolls rotate, two preheated films or one preheated vinyl film and one preheated anchor coated cloth are fed between the rolls. Many decorative applications have been found for laminates of thin film produced in this way, but much care must be taken during preheating that they do not melt away or distort, as this would cause wrinkling during the laminating process.

This laminating method provides greater flexibility in manufacturing, though it slightly increases the cost of the finished material. There also seems to be a good possibility that less vinyl can be used to provide a film with physical properties comparable to those of calendered laminates.

Press laminating

The straight hydraulic press, used for rubber processing, has been developed for press laminating several plies of vinyl material. A sandwich, made up of 10 or 12 vinyl sheets, may be placed between the two steam heated platens. The press is closed and a heating and cooling cycle applied, after which the press is opened and the laminated material removed. The need for higher heat, faster changes in the heating and cooling cycle and more consistent overall temperature have helped to spur the development of the automatic presses used today for vinyl surfacing and laminating. The application of pressure and the heating and cooling cycle are both automatically controlled to provide the optimum laminating conditions.

Rotocuring

The last method Mr. Pierce discussed involves a large drum, approximately 6 to 7 ft in diameter, around which runs a band of high tensile steel, which is also looped around two other large idler drums. The pressure

Tool Steel Topics

BETHLEHEM STEEL

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BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

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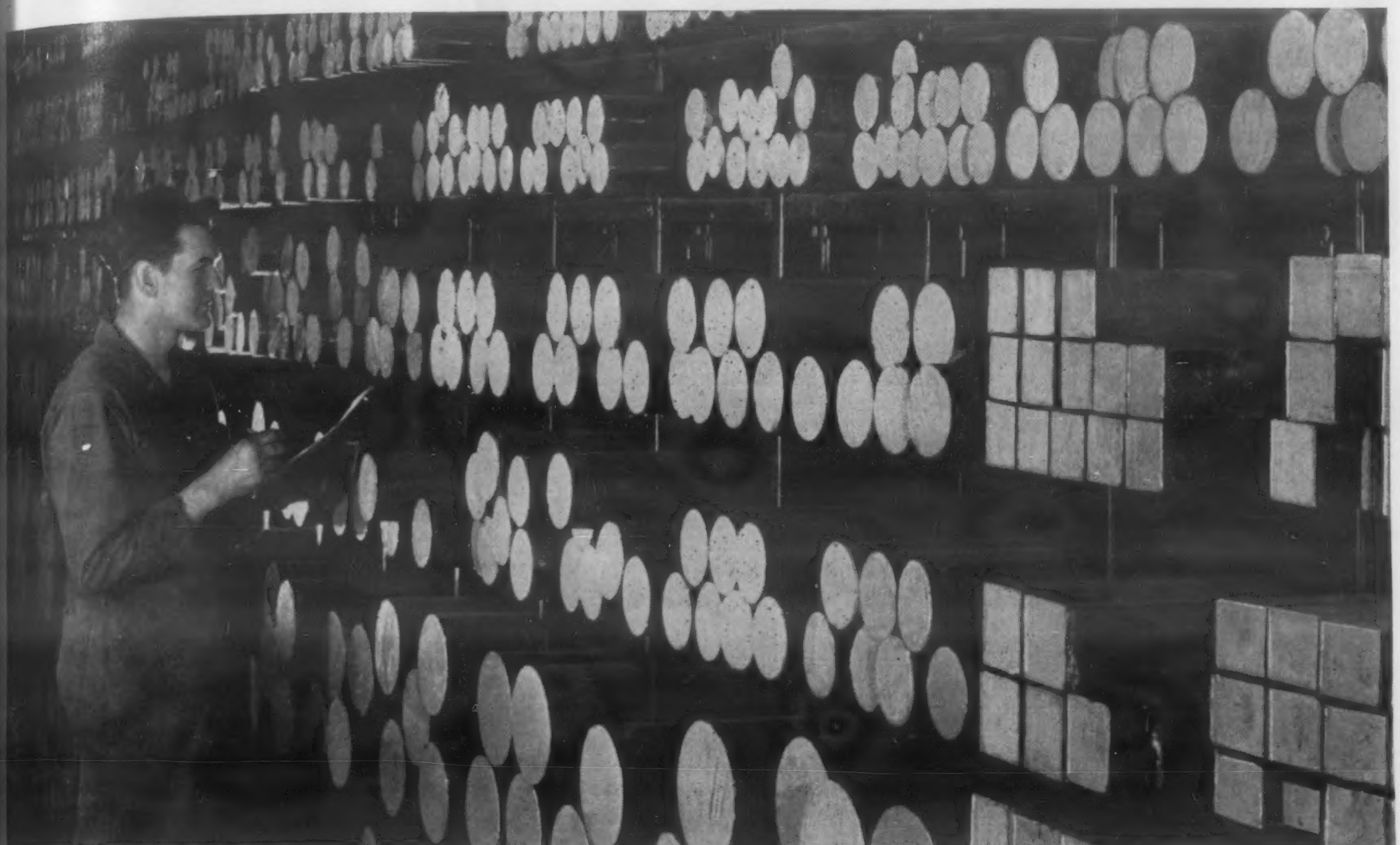

Want Fast Tool Steel Service?

SEE YOUR BETHLEHEM DISTRIBUTOR

Whether you want to order a short bar of tool steel, or merely wish advice about some phase of heat-treating, you're sure to find your Bethlehem tool steel distributor anxious to be of service.

For prompt service is your distributor's middle name. Why else does he make it a point to know your city like a book—its background, its people, its industry? He knows what kinds of steels you are most likely to need, and in what quantities. And so he keeps large stocks of Bethlehem tool steel on hand, in a variety of sizes and quantities, ready to go at a moment's notice.

If you want bars cut to special length, or if there's some tricky phase of metallurgy or any other tool steel problem troubling you, again your distributor is at your beck and call. He's a real friend.

66 HS and XX Team Up in Difficult Nut-Forming Application

The hexagonal punch and doming die, each quenched and drawn to a Rockwell C hardness of 61-63, are used in a cold-forming operation by a maker of nuts. The punch is made of 66 High-Speed. It is doing an outstanding job in holding close tolerances because of its excellent resistance to wear. The XX Carbon Steel die also provides good wear resistance, as well as resistance to shock, its high surface hardness and tough core enabling it to withstand repeated blows of the punch.

BETHLEHEM TOOL STEEL ENGINEER SAYS:

Scale is Tough Stuff

Whenever hot-rolled scaled stock is used in place of cold-rolled stock, the service life of the punches and dies drops to as much as a third of normal, largely because of the abrasion of the scaled hot-rolled surface on the cutting edges of the tools. The peculiarities of each situation determines whether or not such a substitution is economical.

So the question is often asked: What can be done from the tooling end to avoid decreased production? If punches and dies are normally made from water-hardening carbon tool steel, or from manganese oil-hardening steel, decreased tool life can be avoided by changing to a high-carbon, high-chromium steel, such as Lehigh H or S. Such a change would largely overcome the disadvantage of hot-rolled scaled stock. But if high-carbon, high-chromium steels are already being used, effecting an appreciable improvement can be accomplished only through special heat-treatment, such as short-cycle hardening, or nitriding.

For more information, turn to Reader Service Card, Circle No. 360

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applied by the steel strip against the drum is controlled by hydraulically moving the control drum. The heat source is located around ¼ of the drum circumference, and on the top ¼ are cooling shoes which cool the laminated material. Almost ideal laminating conditions are provided since the plies are introduced between the steel strip and the drum, minimum pressure coincides with minimum heat. As the roller turns, there is a gradual but constant increase in temperature and pressure until a maximum of both is reached, after which the cooling cycle starts. There then follows a gradual reduction of both pressure and heat until maximum cooling and minimum pressure are reached at the end of the cycle. The combination during the cycle aids in producing strain-free sheets with minimum shrinkage and distortion. Other advantages of the method include continuous-roll laminating, close gage tolerance and no layup of the material into sandwiches as is necessary with the platen press.

Difficulties of vinyl laminating

Mr. Pierce concluded with a brief summary of some of the continual difficulties encountered in laminating vinyl materials. These difficulties make tight process control essential no matter which of the laminating methods are used. They are:

1. Vinyl chloride is a poor heat conductor resulting in difficulty in driving heat through large masses.

2. Due to heat degradation, properties of vinyl chloride laminates will be affected by the process.

3. Coefficient of linear expansion of polyvinyl chloride is high, which may cause strained sheets.

4. The surfaces of the two sheets may merely adhere without complete lamination if the fusing temperature is not reached or insufficient pressure is applied.

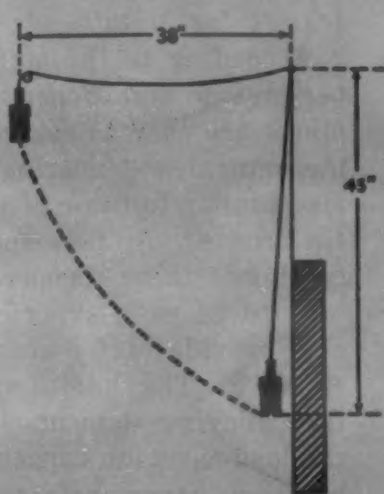
(More Contents Noted on page 164)

"Shock-resistant **G-E RUBBER-PHENOLICS**

DEFIED THIS GRUELING IMPACT TEST

—assured UL approval for our Plugmaster!"

—reports Russ Towers, Engineer, Sperti Faraday, Inc., Adrian, Mich.



UL impact test: Plugs are exposed to 392 F for 24 hours, then dropped on 39" cords through a 90° arc against a maple block.

"To obtain Underwriters' Laboratories approval, our Plugmaster cord plugs had to withstand 1,000 drops against a maple block. When our regular plastics failed to meet this test, we switched to General Electric rubber-phenolics. Result? Our cord plugs now averaged a *minimum* of *3,000 drops*—and many were still intact after 10,000 impacts!"

Sperti Faraday Plugmaster cord plugs are molded by Peerless Molded Plastics, Inc., Toledo, Ohio, of G-E rubber-phenolics.

Where can YOU use shock-resistant G-E rubber-phenolics?

Shock-resistant G-E rubber-phenolics offer you an excellent opportunity to use plastics for applications where high impact strength is a "must." They produce parts which resist breakage in assembly and service, accommodate large metal inserts without cracking, and permit lightweight designs without heavy reinforcement. Where can *you* benefit by them? Ask your molder about these amazing impact materials or send the coupon for a *newly expanded* case history brochure.

Progress is our most important product

GENERAL ELECTRIC

General Electric Company
Section 1416-4A,
Chemical Materials Dept.
Pittsfield, Massachusetts

Please send me a free copy of "Design File —G-E Rubber Phenolics." I want this information for: ( ) Reference purposes only ( ) An immediate application on__________

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Firm__________

Street__________

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• **For more information, turn to Reader Service Card, Circle No. 402**

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New Alloys Sought To Replace Tin Bronzes

In Germany, several hundred alloys have been tested in an attempt to find a copper-base casting alloy, preferably tin-free, that would be less expensive than tin bronzes, but possess equivalent properties. Three groups of alloys, copper-arsenic, copper-antimony, and copper-lead-silicon, seem the most promising, according to E. Vaders, reporting in the September issue of *Zeitschrift für Metalkunde*.

According to the author, copper-arsenic and copper-antimony alloys are easy to cast and have mechanical and bearing properties similar to those of the usual tin bronzes. As permanent mold castings, these properties are said to be even superior. They also provide better abrasion resistance. The addition of further alloying elements improved the load-carrying capacity of the bearings, hence preferred compositions are complex rather than binary alloys.

Copper-lead-silicon alloys give surprisingly good bearing and mechanical properties that are said to surpass those of standard and special tin and lead-tin bronzes. The ability to function without lubrication and the abrasion resistance are likewise superior. Though exact compositions are not revealed, the author claims that the optimum composition contained six different alloying elements. This type of alloy proved particularly satisfactory for permanent-mold casting. Vaders concludes that these alloys in most cases can be used to replace the more costly tin bronzes.

New Gages For Metallic Coatings

Three new instruments for non-destructive measurement of thicknesses of electrodeposited coatings have been developed recently by the National Bureau of Standards. The operation of all three devices depends on the difference in electrical conductivity between the plated mate-

• For more information, turn to Reader Service Card, Circle No. 351

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rials and the base metal, but each is designed for a specific type of application. One is suited for work on small parts with sharply curved surfaces; one was developed for determination of thickness of silver plating on stainless steel, though it can also be used for various other combinations; and the third can be used to measure plating thicknesses on interior, inaccessible surfaces. With appropriate calibration, they all can be used on magnetic or non-magnetic surfaces. The operation of the instruments is described in the October issue of *Metal Finishing.*

Small, contoured parts

The Dermitron, developed by A. Brenner and J. Garcia-Rivera with the assistance of B. Wagoner, Jr., and R. Hill, all of NBS, employs a small probe coil which is held against the specimen. By using a high frequency current, an eddy current can be induced in a thin surface layer of the material. The depth of penetration of the induced current is inversely proportional to the square root of the frequency of the current and directly proportional to the resistivity of the metal. If the coating and the base metal have different conductivities, the effective conductivity of the composite surface layer will depend to a large extent upon the thickness of the coating. And this in turn will determine the magnitude of the induced eddy current.

The magnitude of the eddy current is measured, in the Dermitron, through the effect of the magnetic field set up by the eddy current in opposition to that of the source current. The opposition of the two magnetic fields lowers the impedence of the high frequency coil, permitting more current to pass through it. The current flow is registered on a meter and the plating thickness is determined by plotting this reading on standard calibration curves, in comparison with values determined by placing the probe coil on the unplated base metal.

(Continued on page 168)

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Measures silver plate on stainless

The Phase-Angle Thickness Gage, originally designed for measurement of the thickness of silver plate on stainless steel wave guides, was developed by W. Yates and J. Queen of the Bureau. The probe consists of a mutual inductance transducer and a shielded buckout transformer, which is held within about ⅛ in. of the specimen. The two elements are electrically connected and excited with r-f current in opposition, producing output voltages whose phase difference is responsive to the conductance of the sample. A phase meter, calibrated in mils of silver applied to a 0.037 in. base of stainless steel, gives direct thickness readings based on the effective conductivity of the composite sample.

Measures inaccessible areas

Developed by M. Davidson and N. Rahal of NBS, the Waveguide Plating Quantity Indicator was originally intended for measuring—from the outside—the amount of silver plated on the interior of an L-shaped steel waveguide. The instrument indicates plate thickness by measurement of the conductance of the plated wall. The local conductance is measured by passing a known amount of direct current through a portion of the waveguide wall, using a pair of electrodes or probes. By measuring the potential between two other points in the neighborhood of the current probes, the conductance can be determined provided the current flow is laminar, and the linear dimensions of the material are several times greater than the probe spacing.

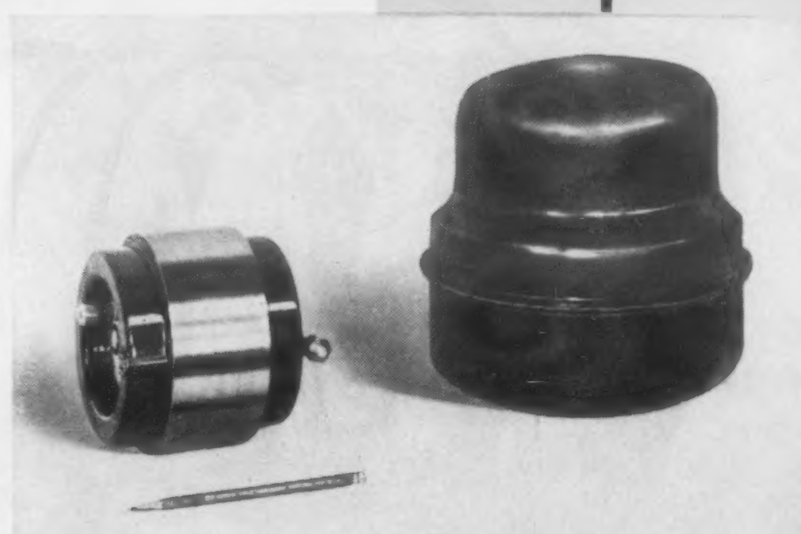
The circuit is designed so that a constant voltage is maintained across the potential probes by varying the current through the current probes. The current required to maintain the constant potential is directly proportional to the conductance of the material, and will therefore vary directly with changes in the thickness of the plate.

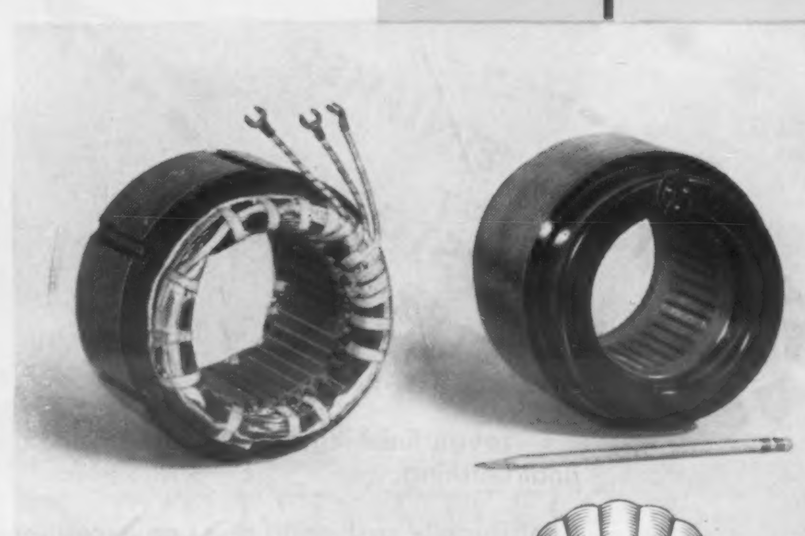
(Book Reviews on page 170)

with the help of EPON® RESIN...

Motor stator becomes pump housing as well–

in new, ultra-compact, refrigeration motor-compressor





New Compressor (left) takes only 27% of the space of a conventional unit (right). It has only 10% as many parts, weighs 58% less, and will cost much less to produce.

Assembled stator (left). Finished stator (right) has been potted with Epon resin formulation. New compressor was developed by Wetmore Hodges and Associates, Redwood City, California.

Why not combine the pump and the motor? Put a gear pump *inside* the motor stator, encase the stator in plastic, and you can build an entire motor-compressor in the space occupied by a conventional motor alone!

Wetmore Hodges and Associates have done just that. But along the way, they ran into an unexpected problem. With the motor stator doubling as the pump housing, it had to be pressure tight . . . free of voids. This was impossible to achieve with standard potting compounds.

After hundreds of plastic formulations were tried, an Epon resin-based compound solved the problem. The Epon-impregnated stator proved to be pressure tight, stable mechanically and fully resistant to Freon at 350 psi, at temperatures as low as –20° F and as high as 250° F. Important too, Epon resin has excellent dielectric properties; is impervious to air, oil and water.

If you, too, are interested in plastics for electrical applications, write for technical bulletin "Epon 828 in Casting Applications."

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For more information, turn to Reader Service Card, Circle No. 339

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Books . . .

Glass Reinforced Plastics. *Edited by Phillip Morgan. Philosophical Library, New York, N. Y., 1954. Cloth 6 by 9 in. 248 pp. Price $10.00.*

This book presents information on the chemistry, design, molding processes and major applications of glass reinforced plastics from the British viewpoint.

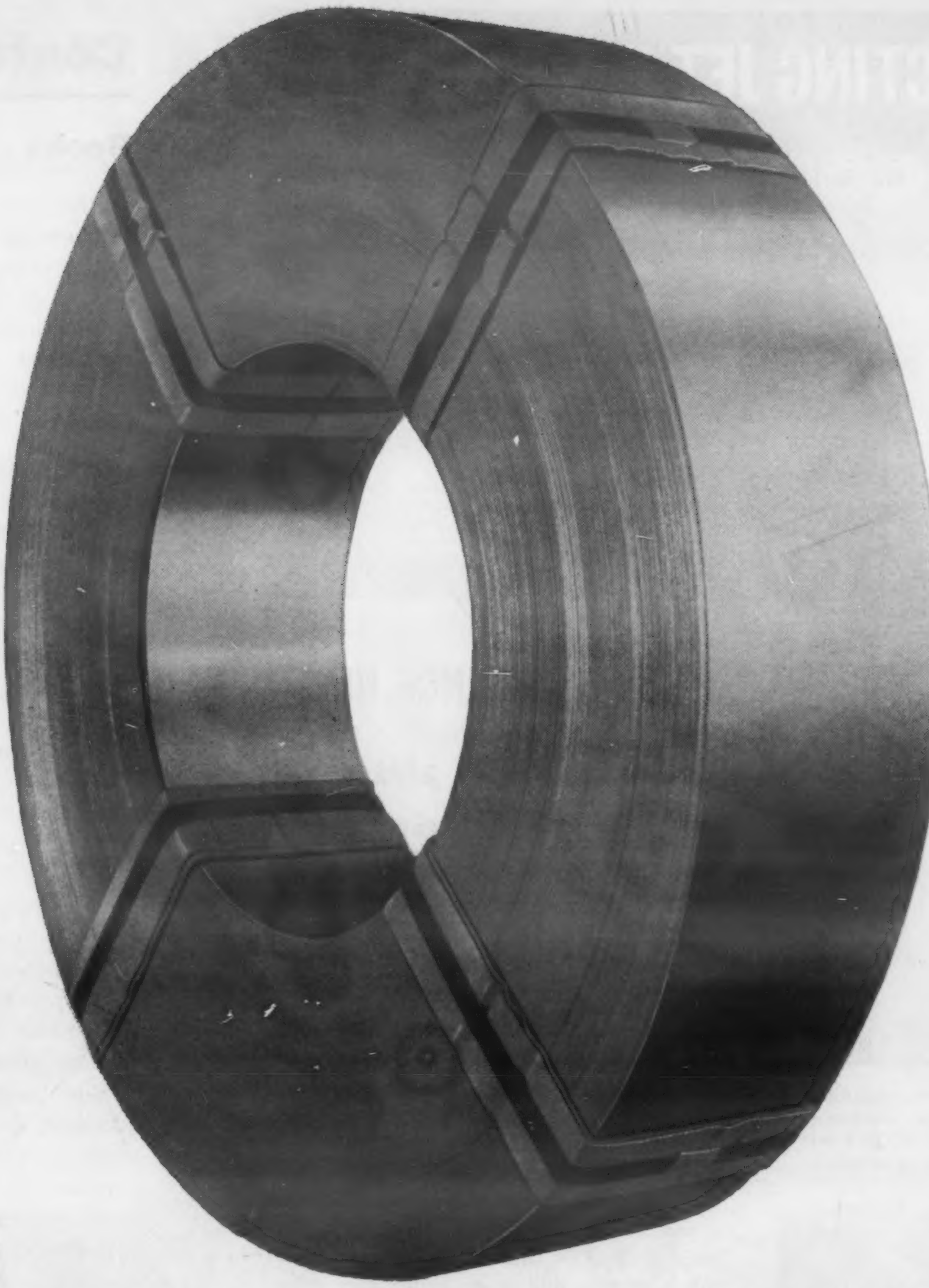
It consists of fifteen chapters, each written by a specialist in the area covered. Subjects include properties of glass fibers, chief resins for bonding these fibers, production methods for laminates and fields of application. Most of the chapters are followed by lists of references to the periodical and patent literature.

Although this volume has been prepared to present the essential facts on this group of materials for the general reader, sufficient detail has been included to make it valuable reading for the specialist in the field.

NASC Titanium Symposium. *Published by National Standards Association, Washington 4, D. C. Looseleaf, 9 by 11 in. 419 pp. Price $4.00.*

This volume contains the report of the first national symposium for titanium standard parts which was sponsored by the Aircraft Industries Association.

The symposium was divided into four sessions dealing with Government Plans and Program; Production; Fabrication; and Aircraft Applications. Each session consisted of a number of formal papers which were presented to stimulate discussion. Subjects covered included Government research projects applicable to the fastener industry, evaluation of titanium as a fastener material, the extrusion of titanium alloys, fabrication of titanium fasteners, application of powder metallurgy to titanium fabrication, fatigue strength of titanium alloy bolts and titanium for jet engine bolts. Each group of papers is followed by a report



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of the discussion which followed the session.

The symposium is an excellent review of the status of titanium as a fastener material in particular and should be read by every engineer interested in that field. All those interested in titanium in general will also find much of value in this book.

Materials for Product Development — 1954. *Published by Clapp & Poliak, Inc., New York 17, N.Y., 1954. Cloth, 9¼ by 6¼ in. 160 pp. Price $7.50.*

Proceedings of the Second Basic Materials Conference are covered in this volume. The Basic Materials Conference was organized to provide a meeting ground where engineers could discuss materials problems broadly. Here, metallurgists, ceramists, plastics engineers and others have the opportunity to learn of developments in related fields which can assist in solving their own problems.

The book is divided into six sections, each containing one or more papers delivered at the conference. The sections discuss materials of the future; metal forming processes such as precision casting, powder metallurgy, forging extrusion and stamping; non-metallic materials including plastics, carbon-graphite, ceramics and glass; adhesive bonding of metals and plastics; corrosion protection; and materials management, a discussion of the procedures for installing and operating a materials department. Each section contains also several pages of questions and answers which featured the discussion period following delivery of formal papers.

The papers and discussion presented in this volume can be read profitably by any engineer who is concerned with materials selection.

Engineering Metallurgy. *E. M. H. Lips. N. V. Philips Gloeilampenfabrieken, Eindhoven, The Netherlands (distributed in the*

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Books . . .

United States by Elsevier Press, Houston 6, Texas) 1954. Cloth, 6 by 9 in. 246 pp. Price $6.25.

This book, a publication in the Philips Technical Library series, was written to help the engineer select the most appropriate material for a specific application.

The work is divided into seven sections covering mechanical properties of metals and alloys, corrosion, phase diagrams and their significance, ferrous alloys, nonferrous metals and alloys, the heat treatment of metals and the working and joining of metals.

The author gives the essential information needed by the engineering student not specializing in metallurgy and the practical engineer to demonstrate the role of metallurgy in engineering design. From the point-of-view of the American student, however, it is unfortunate that the engineering units selected to give mechanical and other properties for example, kg/sq mm and tons/sq in. are not those which he would normally use. A third set of values in psi, for example, would have added to the utility of this book for American readers.

Nickel in Iron and Steel. *A. M. Hall. John Wiley & Sons, Inc., New York, N.Y., 1954. Cloth, 6 by 9 in. 595 pp. Price $10.00.*

This is the second in the new series of Alloys of Iron Monographs sponsored by the Engineering Foundation. The book is a comprehensive review of the important published data on the use of nickel as an alloying element in steel and cast iron.

The book is divided into 15 chapters, the first dealing with the occurrence of nickel and the refining of nickel ores. The rest of the book is concerned with a discussion of the effects of nickel additions on physical and mechanical properties, structure, heat treatment, corrosion resistance and weldability. Cast and

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wrought steels and cast irons are discussed. A bibliography of almost 800 references is included. Like the preceding books in the series, this monograph has been reviewed in manuscript form by a committee of experts in the field.

This book should be on the reference shelf of every metallurgist and engineer concerned with the selection or specification of ferrous metals.

The Riveting of Aluminum. *Published by The Aluminum Development Association, London, England, 1954. Paper 5 by 8 in. 63 pp. Price 30¢.*

The first edition of this bulletin dealt with rivets up to ⅜-in. diameter and was largely concerned with aircraft practice. In revising the publication, coverage has been broadened to include the needs of users in riveting every type of structure. The bulletin opens with discussion of certain factors of a general though fundamental character such as the choice of rivet material, range of rivet sizes and head shapes available, brief notes on the manufacture of rivets and a discussion on the factors of design of riveted joints. The following sections deal with the riveting of light assemblies and of large structures. Appendices include notes on the mechanical testing of rivets and on their heat treatment and tables of rivet lengths related to grip thickness and rivet diameter.

Mechanical Failures of Metals in Service. *by John A. Bennett and G. Willard Quick. Published by National Bureau of Standards, Washington 25, D.C. 1954. Paper 8 x 10 in. 36 pp. Price 30¢. (Order from Government Printing Office, Washington 25, D.C.)*

This circular (No. 550) describes 35 cases representing the most frequently observed types of failures in metal parts. The characteristics by which the various types of fractures can be

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recognized are discussed, and recommended precautions that should be observed to reduce mechanical failure of metals in service are included.

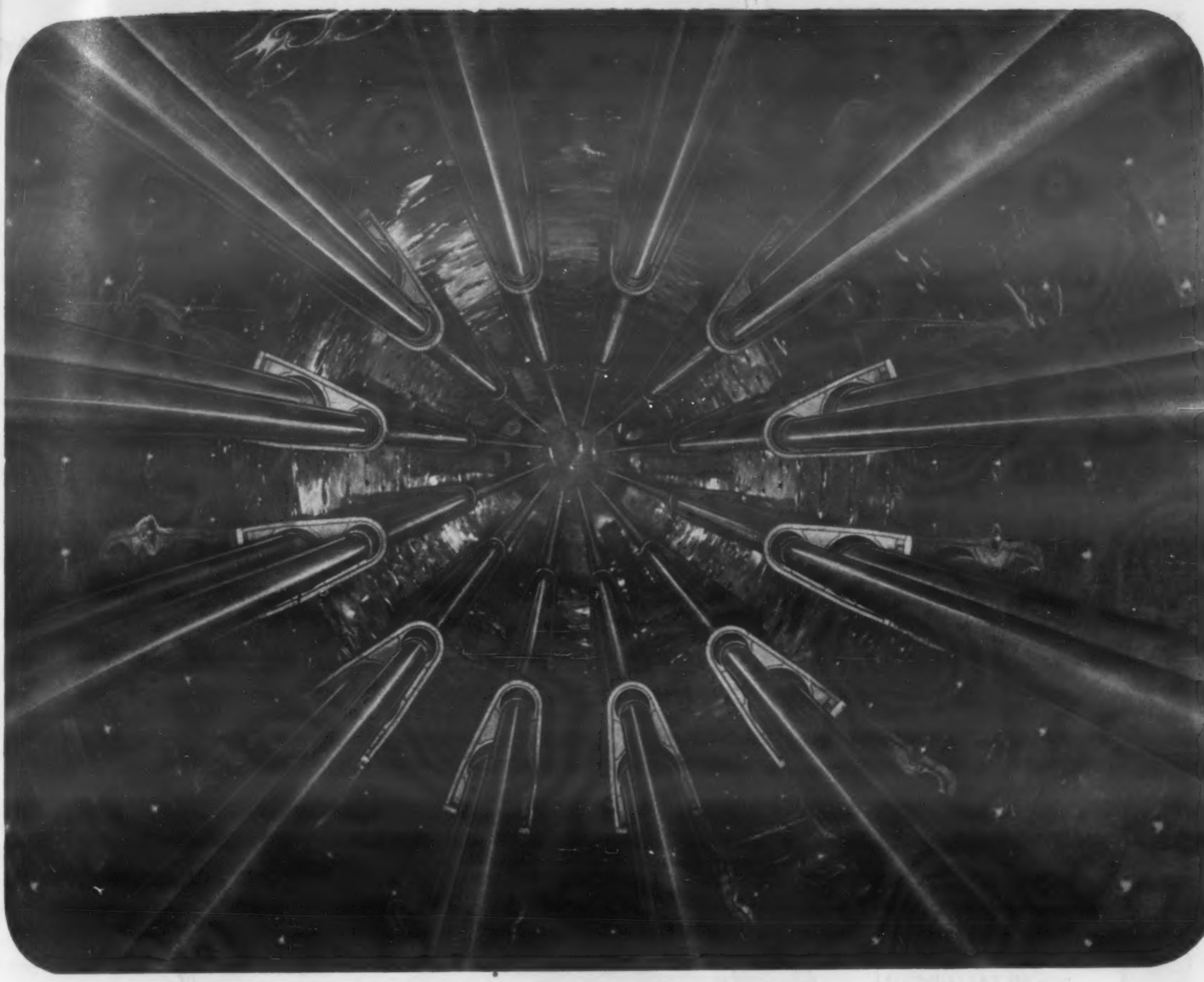
Tentative Specifications for Nickel and Nickel-Base Alloy Covered Welding Electrodes. *American Welding Society, New York, N.Y., and American Society for Testing Materials, Philadelphia 3, Pa., 1954. Paper, 6 by 9 in. 12 pp. Price 25¢.*

Here are standard requirements for nickel and nickel-base alloy covered welding electrodes. These new Specifications, issued jointly by the AWS and ASTM (AWS Designation A5.11; ASTM Designation B295), cover electrodes for welding nickel and nickel-base alloys individually to themselves and also for welding these materials to steel. Also included are filler metals for welding the clad side of nickel-base alloy clad steels. Twelve classifications of filler metal are established by these specifications including all the commonly used materials. This involves, among others, Nickel, Monel, K Monel, Inconel, Inconel X, as well as various Hastelloy alloys.

Reports . . .

Photoelastic Plastics Epoxy Adhesives and Castings Resins as Photoelastic Plastics. *J. D'-Agostino, D. C. Drucker, C. K. Liu, C. Mylonas, Brown University, Graduate Division of Applied Mathematics, Providence, R. I., Apr. 1954. PB 111456, 18 pp, photographs, graphs, tables. Available from Office of Technical Services, U. S. Dept. of Commerce, Wash. 25, D. C. $.75.*
Results are reported on the elastic and photoelastic properties of epoxy resins: Armstrong C-1, C-2, C-4, C-6, C-9, Cycleweld C-14, Araldite CN501, CN502.

Experiments With Composite Models. *C. Mylonas, Brown University, Graduate Division of*



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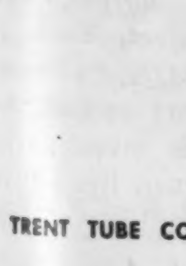
TRENTWELD stainless steel tubing gives economical, trouble-free service over long periods of use. It's an ideal choice, for example, for applications such as the 60-foot rotary kiln dryer you are looking into in the photograph above . . . operating at high temperatures and where corrosive conditions are encountered.

In fact, you just can't buy better tubing than TRENTWELD for any application. That's because TRENTWELD stainless and high-alloy *welded* tubing is a product of tube mill specialists. Each tube has a uniformly sound weld indistinguishable from the parent metal and just as strong and corrosion-resistant.

Whether or not your job is as large and complex as a rotary dryer, you can specify TRENTWELD tubing with confidence. And when it comes to tubing sizes and finishes, Trent offers the widest range in the industry . . . from 1/8" to 40" O.D. and up. Next time you have a job involving tubing, remember—you can make it better with TRENTWELD.



FREE—Write for your copy of the new TRENTWELD price calculator. Just a tug at the selector slide gives you complete price information and weight per foot of the tubing size and grade you need. Better send for your free copy now.

TRENTWELD

STAINLESS STEEL TUBING

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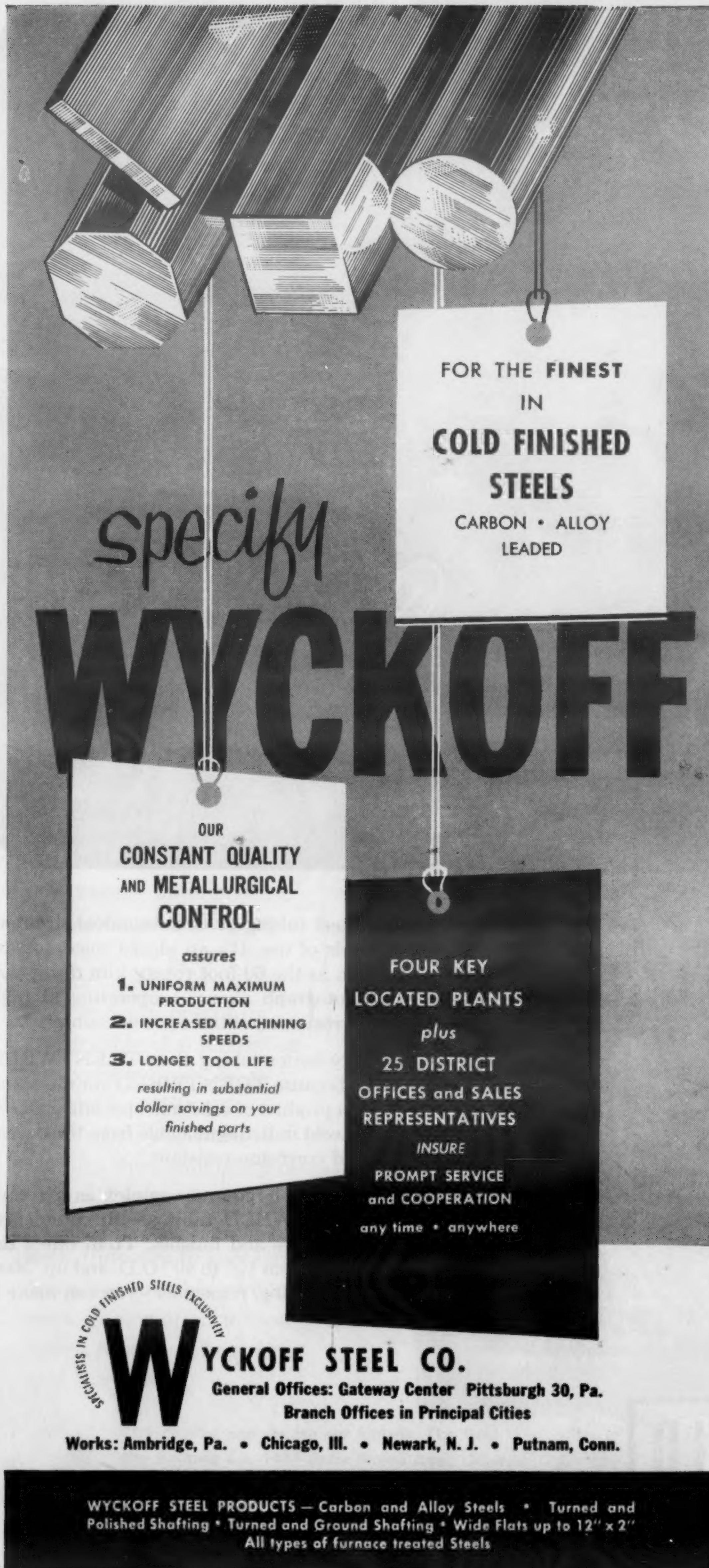
For more information, turn to Reader Service Card, Circle No. 417



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Applied Mathematics, Providence, R. I., Jan. 1954. PB 114740, 33 pp, photographs, diagrams, graphs, tables. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $2.50, Photocopy $5.25. The paper contains a review of problem and describes development of a new cold setting photoelastic resin for making composite models and its use in the construction of lap and butt joints.

Identifying Plastics Infrared Spectra of Plastics and Resins. *R. E. Kagarise and L. A. Weinberger, U. S. Naval Research Laboratory, May 1954. PB 111438, 41 pp, fold diagram, graphs, tables. Available from Office of Technical Services, U. S. Dept. of Commerce, Wash. 25, D. C. $1.50.* The infrared absorption spectra of ninety-two plastic and resinous materials have been studied in the region from 2 to 15 microns, and transmittance curves are given for 57 representative materials. A useful identification procedure based on the catalog of reference spectra has been devised in order to simplify and speed the process of identifying an unknown plastic or resin. The advantages and limitations of this proposed method are discussed.

Aging of Organic Coatings Development of Methods for Predicting the Service Life of Organic Coatings for Aircraft. Final Report on Contract NOa-(s)8697. *B. G. Brand, E. R. Mueller, E. E. McSweeney, E. N. Wyler, F. C. Todd, A. E. Austin, C. M. Schwartz, and H. R. Nelson, Battelle Memorial Institute, Columbus, Ohio, May 1949. PB 114680, 54 pp, graphs. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $3.00, Photocopy $7.75.* This report summarizes all phases of this investigation which has concerned itself principally with the development

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of possible electrical methods for determining the nature of changes taking place in organic coatings as aging progresses.

Dielectric Materials Research and Development of Composite Dielectric Materials. *H. N. Homeyer, Jr., D. C. Dougall, J. H. Preston, Final Report, 15 June 1952 through 15 Dec. 1953, under Contract No. DA36-039-sc-42465, Connecticut Hard Rubber Co., New Haven, Conn., Dec. 1953. PB 114206, 93 pp, photographs, drawings, graphs, tables. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $4.50, Photocopy $12.75.* This report describes the development and fabrication of composite dielectric materials which maintain high insulation resistance under prolonged exposure to extremes of both humidity and temperature.

Thorium-Aluminum Alloys Analysis of Thorium-Aluminum Alloys. *G. W. C. Milner, J. L. Woodhead, Great Britain Ministry of Supply, Atomic Energy Research Establishment, Apr. 1954. PB 114886, 10 pp, tables. Available from British Information Services, 30 Rockefeller Plaza, New York 20, N. Y. $.45.*

Corrosion Corrosion Tests of Metals and Ceramics. *By the staff of the Division of Chemical Engineering. Compiled by L. D. Yates, U. S. Tennessee Valley Authority, 1951. PB 114413, 63 pp, photographs, drawings, diagrams, tables. Available from Superintendent of Documents, Government Printing Office, Wash. 25, D. C. $.20.* This report is a compilation of comparative corrosion rates of many commercial metals ceramic materials in reagents such as mineral acids and salt solutions. Tests were made in phosphoric and nitric acids, fluorine compounds, acidified magnesium chloride, copper ammonium acetate, and ammonium nitrate.

(Reports continued on page 184)

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Titanium Carbide Diffusion of Cobalt, Iron and Nickel into Titanium Carbide. Summary Report, Oct. 1950—Jan. 1952, under Contract No. AF 33 (038)–16190. *Robert C. Turnbull and W. G. Lawrence, New York State College of Ceramics, Alfred, N. Y., Jan. 1952. PB 114896, 7 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $1.50, Photocopy $1.50.*

Fracture of Steel Ductile Fracture of Metals: Mechanical Anisotropy in the SAE 4340 Steel. *Davis S. Fields, Jr., Walter A. Backofen, John Wulff, Massachusetts Institute of Technology, Dept. of Metallurgy, Metals Processing Division. Sept. 1953. PB 111423, 29 pp, photographs, diagrams, graphs, tables. Available from Office of Technical Services, U. S. Dept. of Commerce, Wash. 25, D. C. $1.00.* The tensile fracture characteristics after various amounts of torsional prestrain have been studied in specimens of SAE 4340 steel of three grades: vacuum-melted, aircraft quality, and commercial quality.

Testing Rubber Development and Standardization of Test Methods for Evaluating Rubber. Report No. 4: Hardness measurement of rubber at low temperatures. *R. E. Ofner, U. S. Arsenal, Rock Island, Ill., Apr. 1954. PB 114708, 32 pp, photographs, drawings, graphs, tables (part fold). Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $2.50, Photocopy $5.25.* Performance characteristics of several hardness testers were developed. These were to measure the hardness of rubber compounds over a temperature range of —65 F to room temperature. Eight compounds were tested and six hardness testers utilized. A new tester was developed which has interesting possibilities.

news of ENGINEERS COMPANIES SOCIETIES

NEWS OF ENGINEERS

Herbert B. Gausebeck has been promoted to manager for program development at Armour Research Foundation, Illinois Institute of Technology.

Dr. Maurice J. Day has been appointed director of research and development, Crucible Steel Co. of America. Dr. Day was formerly associated with the Armour Research Foundation, Illinois Institute of Technology, as assistant director in charge of program development.

Dr. A. R. Matheson has joined General Plate Division of Metals & Controls Corp. as product manager.

George W. Kessler has been appointed chief engineer of Babcock & Wilcox Co.'s Boiler Div.

Abraham Krasnoff has been named vice president, Micro Metallic Corp., a Pall Filtration Company.

Charles J. Chaban has been appointed research director and **William A. Corry** has been named laboratory manager of Landers Corp.

Maurice W. Horrell, director of engineering and assistant general manager of the Bendix Computer Div. at Los Angeles has been promoted to general manager. Other major appointments announced by Bendix Aviation Corp, are: **E. K. Foster** as group executive in charge of the Bendix Radio, Bendix Television and Broadcast Receiver, divisions, York and Cincinnati; and **Howard Walker** as general manager of the York, Pa., division.

Clarence E. Hawke, vice president, Carborundum Co. and general manager of the Refractories Div., has retired from active direction of the Division. **Boyd M. Johnson,** formerly assistant general manager of the Division, has been appointed to succeed Mr. Hawke.

(Continued on page 188)

A leading West Coast metal fabricator is helping to make the classical varnished-wood phone booth as obsolete as the hand-crank telephone. Important factor in the redesign of this familiar landmark was the availability of *custom-designed* Harvey Aluminum extrusions, which make up the frame and doors of the new booth.

Booths are now fabricated in fewer steps and can be shipped knocked-down in compact cartons. Installation at the site takes only minutes, with just four screws required for complete assembly. The design blends with the decor of modern stores and lobbies, and, best of all, the completely weatherproof booth can be installed out-of-doors, where wooden booths deteriorated rapidly. Aluminum construction makes roadside phone service practical. Such *double* benefits . . . a product both better to make and better to use . . . follow naturally when you use a Harvey extrusion, *custom-designed* for your product.

The Men of Harvey have a single objective... making aluminum work for *you*. Harvey extrusions are a *custom* product . . . each is the result of a Harvey Field Engineer sitting down with the customer's designers and jointly planning how the product can be improved with this modern metal form. Our newest brochure "Aluminum Extrusions" is a valuable reference source. We will be glad to send you a copy.

MAKING THE MOST OF ALUMINUM . . . FOR EVERYONE

HARVEY Aluminum

HARVEY ALUMINUM SALES, INC., TORRANCE, CALIFORNIA
BRANCH OFFICES IN PRINCIPAL CITIES

An independent producer of aluminum extrusions in all alloys and all sizes; special extrusions, press forgings, hollow sections, structurals, rod and bar, forging stock, pipe, tubes, impact extrusions, aluminum screw machine products and related products. Also similar products in alloy steel and titanium on application.

* For more information, turn to Reader Service Card, Circle No. 468

news of ENGINEERS

Richard T. Myer has been appointed chief metallurgist of the Aluminum Fabrication Div., Kaiser Aluminum & Chemical Corp.

John A. Morgan has been elected vice president of Glass Fibers Inc. and appointed general manager of the Western Div. **M. Dean Worcester,** formerly general manager of the Western Div., has resigned as vice president of the company.

Ara A. Cambere, formerly vice president and director of Oliver Iron and Steel Corp., was named assistant to the president, Stewart-Warner Corp.

Hjalmar Nilsson, plant engineer of Magnesium Co. of America since 1947, has been appointed chief engineer.

Dr. William Firestone has been appointed to the newly created position of assistant chief engineer, Research Dept., Communications and Electronics Div., Motorola.

Richard B. Young, former treasurer of Acushnet Process Co., has been elected vice president of the company and general manager of the Rubber Div.

Dr. William R. Clough and **Arthur L. Geary** have joined Electro Metallurgical Co.'s Metal Research Laboratories as senior research assistants.

Hjalmar A. Anderson was recently appointed chief project engineer, Lindberg Industrial Corp.

Cyrus E. Brush has been named vice president, American Brake Shoe Co.

Edwin C. Evans has been made vice president and assistant general manager, Behr-Manning Corp.

Fred W. Arndt has been appointed chief engineer, Heil Process Equipment Corp.

Carl J. Pfeifer has been elected president of National Cored Forgings Co., Inc.

Harry C. Platt has been elected executive vice president, Engineered Castings Div., American Brake Shoe Co.

(Continued on page 191)

news of | ENGINEERS

R. G. Gehlsen has been appointed manager, electrical connector products, Joy Manufacturing Co.

Joseph W. Kennedy, Jr. has been named vice president in charge of Copperweld Steel Co.'s Ohio Seamless Tube Div.

Dr. Leland G. Cole has been appointed director of the dynamics laboratory, Aeronautical Div., Robertshaw-Fulton Controls Co. Other new staff appointments to the Division's research and development laboratory are **Dr. W. M. Roberds** and **Maynard D. McFarlane,** as research scientists, and **C. J. Thompson** as chief design engineer.

J. Walter Gulliksen, formerly general superintendent, Worcester Pressed Steel Co., has been appointed general factory manager, Chase Brass & Copper Co., Inc.

Dr. Robert H. Krieble has been named manager of the Chemical Development Dept., Chemical and Metallurgical Div., General Electric Co. Dr. Krieble succeeds **Dr. Alphonse Pechukas** who has been appointed to the post of Consultant-Materials and Processes, Engineering Services Div.

Dr. R. L. Bateman has been appointed to the newly created position of director of product development, Carbide and Carbon Chemicals Co., a Division of Union Carbide and Carbon Corp. **W. A. Woodcock** has been appointed manager, Fine Chemicals Div., to succeed Dr. Bateman.

Clinton B. Fleming has been appointed chief industrial engineer at Laclede-Christy Div., H. K. Porter Co., Inc.

Douglas C. Albright has been named director of manufacturing and **Donald W. Coulson,** production superintendent, Coleman Co., Inc.

Linwood A. Walters has been appointed development manager of the Durite Dept., Chemical Div., Borden Co.

Col. Richard L. Hopkins has been appointed vice president, American Electro Metal Corp.

(Continued on page 192)

For more information, Circle No. 387 ➤

news of ENGINEERS

Martin L. Carson, formerly general manager of Allis-Chalmers Manufacturing Co.'s Terre Haute Works, has been placed on special assignment in the office of the vice president in charge of the General Machinery Div. Mr. Carson will be replaced by **L. W. Long,** formerly general manager of the firm's Boston Works. **John F. Chipman,** assistant chief engineer, Switchgear Dept., steps up to take Mr. Long's position.

William C. Vokolek has been named vice president and works manager of the Franklin Steel Div., Borg-Warner Corp. **Edward W. Clark,** works manager of the Calumet Steel Div. of the company has been made a vice president of the division and will also continue to serve as works manager.

Andrew R. Wardrop has been appointed general manager of Ford Motor Co.'s Dearborn General Manufacturing Div. Mr. Wardrop was previously assistant general manager of the company's Metal Stamping Div.

NEWS OF COMPANIES

Pennsylvania Salt Manufacturing Co. has acquired **Gilron Products Co.**

Bendix Aviation Corp. has announced that its Eclipse-Pioneer Foundries Div. will now be known as Bendix Foundries.

Printed Circuits, Inc. 36 Tunxis Ave., Bloomfield, Conn., is a new company organized for the design, engineering and manufacture of all types of printed circuit boards.

California Metal Enameling Co. has announced acquisition of **Seaporcel Pacific, Inc.**

Carborundum Co. has just completed two new warehouse and office buildings near Los Angeles and San Francisco, and has reorganized sales, engineering and other services in the West into what is now designated the Pacific District.

(Continued on page 194)

For more information, turn to Reader Service Card, Circle No. 381

news of COMPANIES

Pittsburgh Plate Glass Co. recently opened its new Basic and Applied Research Laboratories facilities at Springdale, Pa.

Arvin Industries, Inc. has organized an Electronic Products Div. to specialize in subcontract work on military and industrial electronic projects.

Continental Can Co. has purchased **Tenco, Inc.** of Winona, Minn., manufacturers of plastic pipe fittings. The Tenco line will become a part of Continental's Plastic Div.

Cast Optics Corp. announces the transfer of its facilities from Riverside, Conn. to 123 Newman St., Hackensack, N.J.

Van der Horst Corp. has announced a $400,000 expansion program for its Texas plant located in Terrell, Texas.

Pacific Tube Co., Los Angeles, recently broke ground for a major expansion of its Stainless Steel Tube Pickling facilities which will double its present capacity.

AiResearch Manufacturing Co., largest division of **Garrett Corp.** recently celebrated its 15th birthday.

Jones & Laughlin Steel Corp.'s new warehouse and container plant in Lancaster, Pa. began operations as of Dec. 1.

Krouse Western Laboratories, Inc., 6048 Hazeltine Ave., Van Nuys, Calif. is a new laboratory specializing in fatigue testing of materials, and repeated loading of parts and components.

Enamelstrip Corp.'s new half-million dollar plant at Allentown, Pa. is scheduled for occupancy on Jan. 1, 1955.

Torrington Manufacturing Co. has changed the name of its Spring Machinery Div. to the Wire Forming Machinery Div. so that the name will more adequately describe the function of that particular phase of the firm's machinery operation.

Ace Heat Treating Co. has announced a change of name to Ace Metal Treating Corp. in line with

THE YOLOY FAMILY

High in resistance to corrosion, shock and vibration, easy to fabricate, easy to weld.

YOLOY
(Nickel-Copper)
Low Alloy High Strength Steel

YOLOY E
(Nickel-Chrome-Copper)
Low Alloy High Strength Steel

YOLOY C
(Chrome-Copper)
Corrosion Resistant Steel

Body Model S-7, with load capacity of 187 cu. ft. Boyertown Auto Body Works, Boyertown, Pa.

YOLOY IS AVAILABLE in sheets, plates, strip, pipe, mechanical tubing, bars, shapes and cold finished bars.

Boyertown truck bodies, such as Model S-7 shown above, are serviceable for many EXTRA YEARS, because they are fabricated from Yoloy "E" sheets.

Due to its nickel-chrome-copper content, this tough corrosion-resistant, low-alloy high strength steel reduces dead weight, resists corrosion and lengthens body life. Yoloy "E" is also outstanding for its resistance to vibration and shock—even at the lowest outdoor temperatures.

For types of Yoloy available for prompt delivery, phone our nearest District Sales Office.

Youngstown

QUALITY YOUNGSTOWN SERVICE

THE YOUNGSTOWN SHEET AND TUBE COMPANY *Manufacturers of Carbon, Alloy and Yoloy Steel*

General Offices: Youngstown, Ohio - Export Office: 500 Fifth Avenue, New York 36, N. Y.

SHEETS - STRIP - PLATES - STANDARD PIPE - LINE PIPE - OIL COUNTRY TUBULAR GOODS - CONDUIT AND EMT - MECHANICAL TUBING - COLD FINISHED BARS - HOT ROLLED BARS - BAR SHAPES - WIRE - HOT ROLLED RODS - COKE TIN PLATE - ELECTROLYTIC TIN PLATE - RAILROAD TRACK SPIKES

For more information, turn to Reader Service Card, Circle No. 321

news of COMPANIES

expansion of its facilities to include a unique, all-embracing metal-treating service.

Lester Engineering Co. has purchased the **Phoenix Machine Co.** As a result, engineering, production and sales are now integrated under the same management. Lester-Phoenix Inc., the sales agency for the company, will continue under the name as a wholly owned subsidiary.

Norton Co. will add to its electric furnace capacity by building a new plant in Huntsville, Ala.

Minneapolis - Honeywell Regulator Co.'s Micro Switch Div. has opened a new research and product development center in Denver.

Westinghouse Electric Corp. is building a new metals plant at Blairsville, Pa. The multi-million dollar plant for the devolopment and pilot production of new metal alloys and special castings is expected to be completed by Jan. 1.

Air Reduction Sales Co., a division of **Air Reduction Co., Inc.** recently held an open house at its newest liquid oxygen plant in Riverton, N.J.

Drever Co. has moved into a new building at Red Lion Rd. & Philmont Ave., Bethayres, Pa.

The **American Research Corp.** has announced expansion of its Bristol, Conn. plant. The new addition is designed to double the company's manufacturing capacity.

NEWS OF SOCIETIES

Case Institute of Technology has appointed J. F. Wallace as associate professor in its Metallurgical Engineering Dept.

The **University of Oklahoma** will conduct its annual Corrosion Control Short Course, April 5-7 at its Extension Study Center. The program is sponsored jointly by the University and the Central Oklahoma Section of N.A.C.E.

The **Pressure Sensitive Tape Council** at its annual meeting

news of | SOCIETIES

elected Clarence I. Lee, president, Hampton Manufacturing Co., as its president.

New York University has announced that a National Machine Design Conference will be held at the College of Engineering on April 6, 1955. The theme of the conference is Product Consideration in Machine Design. It is part of the observance of the College's Centennial Year.

Peter Muller-Munk, Peter Muller-Munk Associates, has been elected president of the **Society of Industrial Designers.**

The **American Institute of Industrial Engineers** has announced that Phil Carroll, a professional engineer, has consented to give a series of discussions on "Development of Standard Data". The lecture series is scheduled to begin March 15.

The **American Society for Metals** at its recent annual meeting presented the *1954 Medal for The Advancement of Research* to William E. Umstattd, president, Timken Roller Bearing Co. The Society presented its *Sauveur Medal* to Dr. Alexander L. Feild, associate directory of research, Armco Steel Corp.

Gray Iron Founders' Society presented its highest award — the *Gold Medal* — to H. L. Edinger, president, Barnett Foundry & Machine Co. The Society also announced that William S. Thomas, vice president, Emmaus Foundry and Machine Co., Inc., won first prize in the Redesign Contest for 1954. Other winners in the contest were: Russell W. Henke, chief mechanical engineer, Research and Development Div., Badger Meter Manufacturing Co., second place; and Paul C. Nelson, chief engineer, O'Neil-Irwin Manufacturing Co., third place.

The **American Society of Mechanical Engineers** has honored Jay H. Cather as a new fellow of the Society. Mr. Cather has just retired as superintendent of the Utilities Div., Eastman Kodak Co.

(Meetings & Expositions on p. 200)

Meetings and Expositions

AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS, annual meeting. Chicago. Feb. 14-17, 1955.

SOCIETY OF THE PLASTICS INDUSTRY CANADA, INC., annual SPI Canadian conference, London, Ontario, Canada. Feb. 22-23, 1955.

SOCIETY OF AUTOMOTIVE ENGINEERS, passenger car, body and materials meeting. Detroit. Mar. 1-3, 1955.

NATIONAL ASSOCIATION OF CORROSION ENGINEERS, annual conference and exposition. Chicago. Mar. 7-11, 1955.

NATIONAL ELECTRICAL MANUFACTURERS ASSN., winter meeting. Chicago, Mar. 13-18, 1955.

STEEL FOUNDERS' SOCIETY OF AMERICA, annual meeting. Chicago. Mar. 14-15, 1955.

SOCIETY OF AUTOMOTIVE ENGINEERS, production meeting and forum. Cincinnati. Mar. 14-16, 1955.

AMERICAN SOCIETY OF TOOL ENGINEERS, annual meeting. Los Angeles. Mar. 14-18, 1955.

PRESSED METAL INSTITUTE, spring technical meeting. Cleveland. Mar. 16-18, 1955.

AMERICAN SOCIETY FOR METALS, Western Metal Congress and Exposition. Los Angeles. Mar. 28-Apr. 1, 1955.

SOCIETY OF THE PLASTICS INDUSTRY, INC., Pacific Coast Section conference. Palm Springs, Calif. Apr. 13-15, 1955.

SOCIETY OF AUTOMOTIVE ENGINEERS, aeronautic meeting, aeronautic production forum and aircraft engineering display. N. Y. Apr. 18-21, 1955.

ELECTROCHEMICAL SOCIETY, INC., spring meeting. Cincinnati. May 2-5, 1955.

SOCIETY OF THE PLASTICS INDUSTRY, INC., annual meeting. Queen of Bermuda. May 7-15, 1955.

METAL POWDER ASSOCIATION, annual meeting. Philadelphia. May 10-12, 1955.

INDUSTRIAL HEATING EQUIPMENT ASSN., INC., spring meeting. Hot Springs, Va., May 15-18, 1955.

PORCELAIN ENAMEL INSTITUTE, mid-year division conference. Chicago, May 18-20, 1955.

AMERICAN FOUNDRYMEN'S SOCIETY, annual convention. Houston. May 23-27, 1955.

AMERICAN WELDING SOCIETY, Welding Show and Spring Meeting. Kansas City, Mo., June 8-10, 1955.

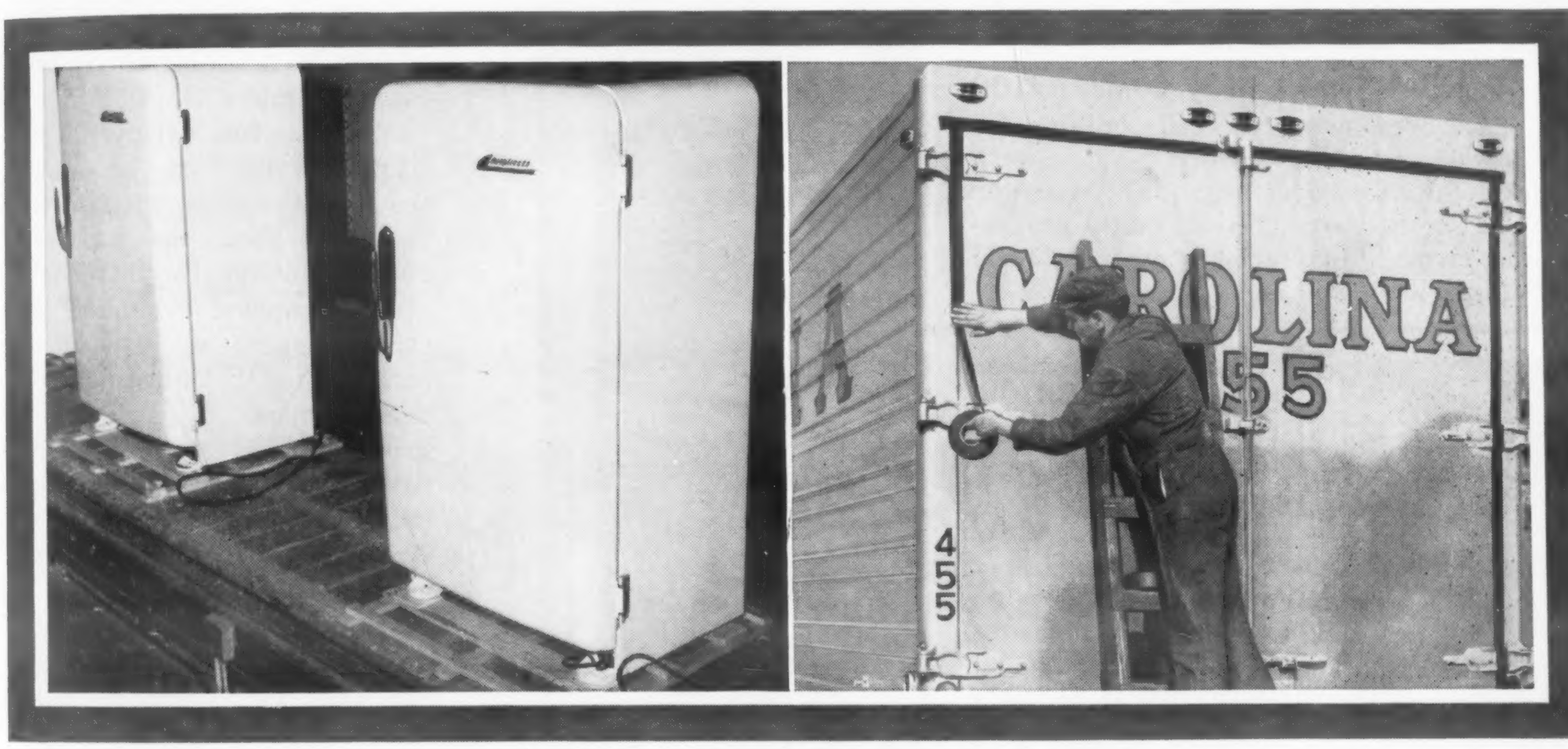
Basic Materials Conference and Exposition. Philadelphia, May 31-June 3, 1955.

Polyken

CONTROLLED STRENGTH

TAPES

SEAL FREEZERS FOREVER OR CARGOES FOR MILES



Polyken Tapes do pretty much the same job in both the applications shown above. In the freezer cabinets, *Polyken* is put on over the inside metal seams. The seal has to be tight and permanent. A leak will cause condensation damage to the insulation.

There can't be any cracks in those trailer doors either. The suction at the rear of a moving truck is so great that rain and snow will penetrate even the smallest cracks and cause damage to the cargo. Here the *Polyken* Tape forms a seal that stands up under weather and vibration from the start to the end of the trip. Then it pulls off easily.

Polyken Tape seals out moisture in both cases . . . but the conditions are different and so are the requirements. That's why the *Polyken* Tape used in the freezer cabinets is not the same *Polyken* Tape used on the trailer doors. To meet the requirements of specific jobs, *Polyken* Tapes have *controlled strength*—the controlled combination of adhesive and backing. Use the controlled strength for your job—do it right—at the lowest possible cost—and save.

The coupon will bring you complete information.

Polyken®

INDUSTRIAL TAPES

Polyken Products Department of The Kendall Company

Polyken, Dept. MM-B
222 West Adams St., Chicago 6, Illinois

Please send me physical properties and further information on *Polyken* Controlled Strength Tapes, and a copy of your Tape Use Manual.

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City__________ Zone____ State______

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News Digest

continued from page 14

customers for these products. In the plastics pipe field alone there are under preparation at the present time two additional manufacturing standards both of which will be a factor in the industry's production of quality pipe, tubing, fittings and valves.

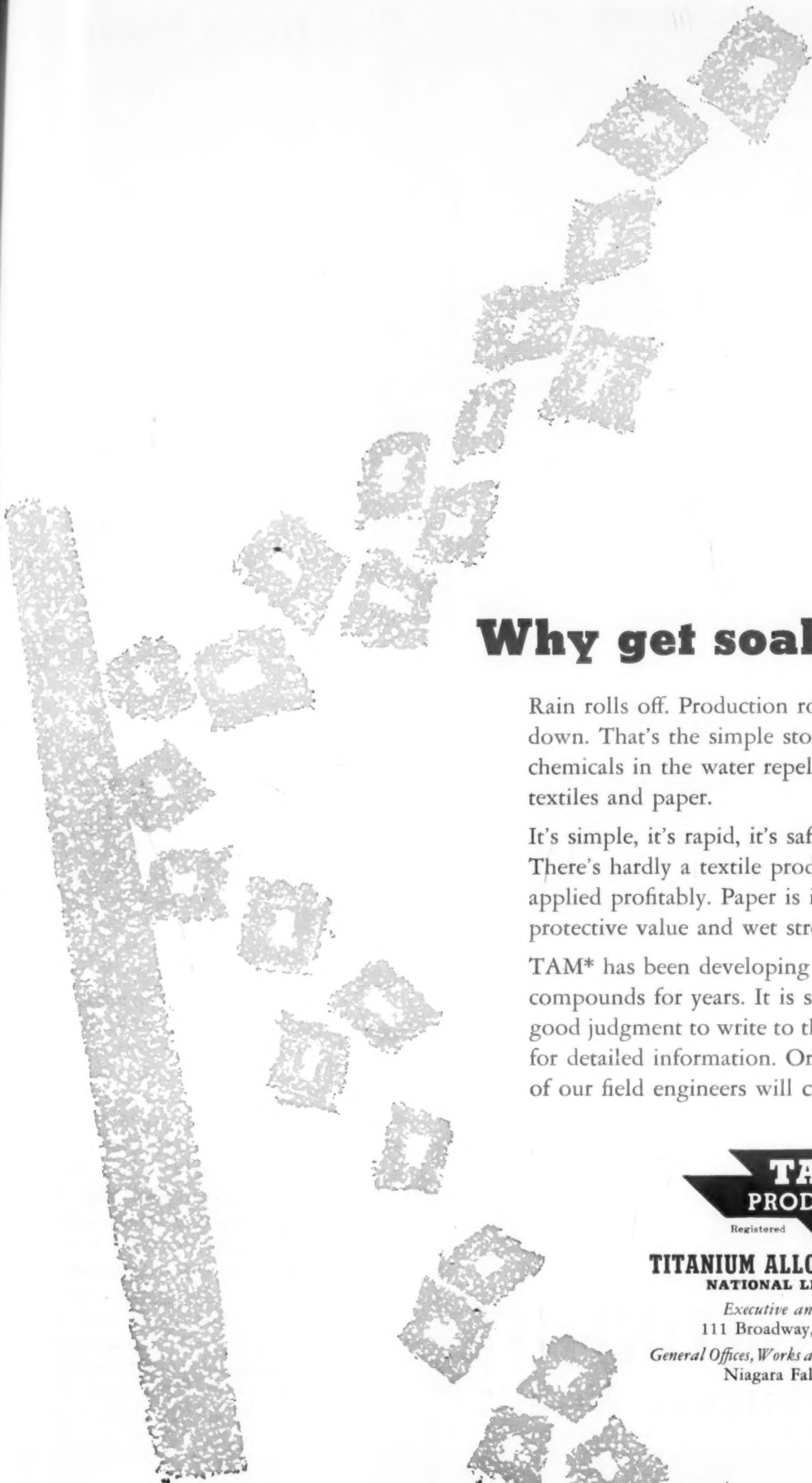
Research continues to be an important part of the industry's thinking for the future. Through The Society of the Plastics Industry, Inc. there are currently two research programs on plastic pipe now under way—one in the National Sanitation Foundation at the University of Michigan, Ann Arbor and the other at The Battelle Memorial Institute, Columbus, Ohio.

Markets for expanded polystyrene appear to be still in the growth stage with sales in 1954 just about the same as in 1953. However, the introduction of new molded expanded polystyrene opens up new market possibilities that have not as yet been tapped. Because of the growing interest in this field SPI has recently established a Cellular Plastics Division to service molders and fabricators of expanded plastics.

In the field of plastics housewares there was a feeling a year ago that the trend of profits and dollar volume was down. However, today that is not the case and plastics housewares manufacturers feel that prospects are much better than a year ago. There is a greater public acceptance for plastics housewares. Inventories at the store level are below normal which, coupled with increasing consumer demand, results in a further upsurge in plastics housewares business.

Many molders of thermosetting and thermoplastic products have experienced a sharp rise in orders beginning in October which has carried through to the end of the year. These companies feel that this upturn will continue well into 1955; that 1955 will be a good year.

In the reinforced plastics area of this industry there was a lot



News Digest

continued

of activity in 1954 but not as much production as had been anticipated a year ago. Production of plastic raw materials used in these products totalled approximately 27,000,000 lb compared with approximately 26,000,000 lb in 1953. Progress in this field continues with the industry concentrating on development of mass production techniques.

The process of vacuum forming thermoplastic sheets made considerable strides in 1954 and this area of the plastics industry appears to be headed for a further period of pronounced growth. Business in this field in 1955 will undoubtedly be much higher than 1954. The appliance field is using increasing quantities of vacuum formed items such as refrigerator inner panelling and liner panels for freezer units. The TV mask business too is becoming an important item, and packaging offers considerable opportunities for development.

Melamine dinnerware which is manufactured according to the quality standard issued by the Department of Commerce, enjoyed a very satisfactory year and indications for 1955 are excellent. There are approximately 15 molders in the United States making this dinnerware according to the standard and their promotion of this quality product to the consumer field, plus the fact that store inventories are down sharply, makes 1955 look most attractive in this area.

Polystyrene plastic wall tile, also made according to a quality standard issued by the Department of Commerce, experienced an increase in demand in 1954, as architects, builders and the consuming public became more conscious of the value of better grade tile. The outlook for 1955 is good.

Plastics pipe manufacturers recorded an increase in production and sales during the last year and it looks as though this will be continued in 1955. Rigid

For more information, turn to Reader Service Card, Circle No. 400

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continued

pipe users in the gas field hold a promise for expanded markets. Competition in this field is quite keen and the proper merchandising of plastics pipe will be all-important to this branch of the industry.

Plastics toy manufacturers experienced a fair year and feel that the 1955 outlook is better as long as they continue to upgrade their products.

Manufacturers of vinyl film, sheeting and coated fabrics which had experienced a decline in business for several years, were able to arrest this trend in 1954 by actively promoting the desirability of purchasing only products made according to the quality standard issued by the United States Department of Commerce.

This educational program which has been carried on among Department Stores, Variety Chains, Buying Offices, Mail Order houses and consumers, encourages the purchase only of products made according to this standard. This program will be continued through 1955 and it is felt that it will start again an upward trend in quality vinyl film consumption.

Machinery and equipment manufacturers continue to keep pace with the steady growth of this industry. There are 5000 to 6000 companies identified with plastics in the United States, and they have provided these manufacturers with a satisfactory year as the plastics industry sought to modernize its plants and reduce its costs. The year 1954 was good and indications are that this will continue into 1955. The export field has been particularly good for some machinery and equipment companies.

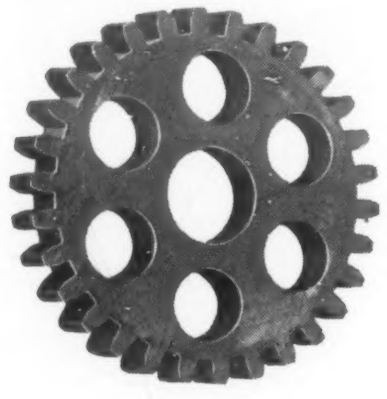
As far as the plastics industry as a whole is concerned, there is a recovery movement clearly in evidence which according to all indications, will be extended through the early months of 1955.

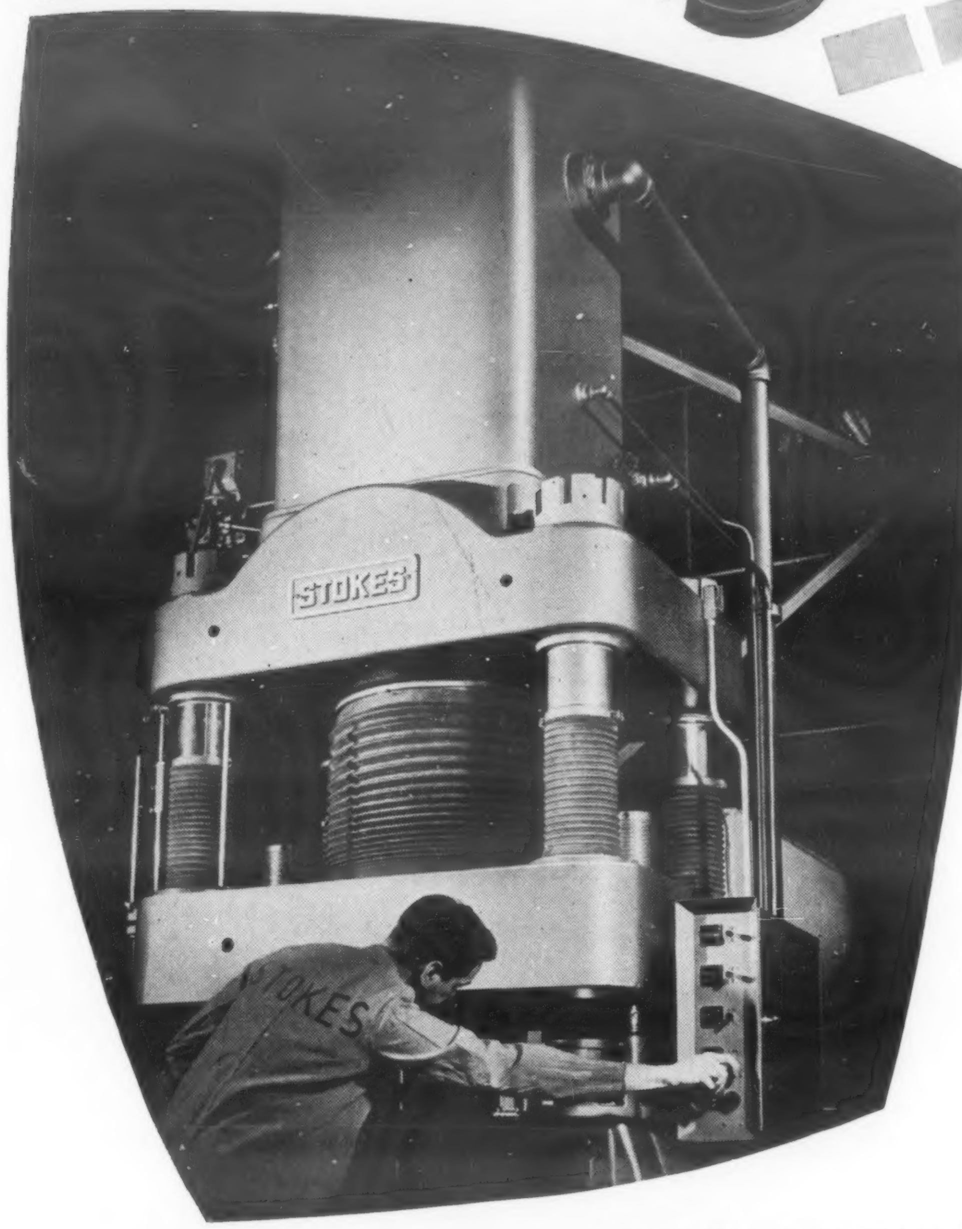
(More News Digest on page 208)

A valve disc sleeve used in the air release mechanism of a Neptune Red Seal petroleum meter was originally made of brass rod stock, then of die-cast zinc (which proved unsatisfactory) and now of powdered brass. Tolerances are ±.001″ on two diameters. The part costs no more than the unsatisfactory die casting and approximately 1/3 that of the machined part.

This oil pump rotor is used in several IBM machines. Saving in cost as compared with machined parts, says IBM, is 84%! Total tolerances of .001″ and .002″ are required. Powder metal processing eliminates all machining operations, which previously required 20 hours per 100 pieces.

Making this intermediate wringer-drive gear of iron and copper powder saves its user, the Whirlpool Corporation, St. Joseph, Michigan, up to $20,000 per year. The part was formerly made from a 3/8″ blank which was pierced, flattened, machined for teeth; wire brushed for burr. Tolerances on the powder metal part are identical with those obtained by machining.





The Stokes 300-ton Model 713 hydraulic powder metal press, a recent addition to the complete line of 16 Stokes fully automatic powder metal presses of 1½ to 500 tons capacity. Powder metal presses of the modern Stokes' line embody THIRTY YEARS of powder metal press research and engineering.

The parts illustrated on this page are made by the Presmet Corporation, Worcester, Mass., custom maker of high-precision powder metal parts . . . like most producers of powder metal parts, a user of Stokes powder metal presses.

Powder Metal Processing
Saves $20,000 a Year on this Part

Parts which are difficult to machine . . . parts which are wasteful of solid metal . . . are made in powder metal at great savings.

Fully automatic compacting of a broad selection of metal powders, pure or mixed, gives wide flexibility in determining tolerances, tensile strength, and functional characteristics, many of them unattainable in solid metal.

Stokes has over thirty years' experience in making presses *specifically* for powder metal processing. Stokes engineers are recognized for their broad contributions to the growing success of powder metal processing . . . will gladly contribute their experience to manufacturers interested in powder metal processing as a means of cutting costs and improving products.

Three booklets available: "Powder Metallurgy Today"; catalog of Powder Metal Presses (#801); and "How to Save Money on Punches and Dies". Send for any or all.

F. J. Stokes Machine Company
Philadelphia 20, Pa.

STOKES

ENGINEERS:
Stokes is continually adding to its engineering and technical sales staffs in the high vacuum, industrial tabletting, powder metal and plastics molding fields. If you can qualify, there may be a position for you.

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News Digest

continued

Better finish *on aluminum die castings simplifies chromium plating, mechanical finishing and application of Alumilite high gloss finishes.*

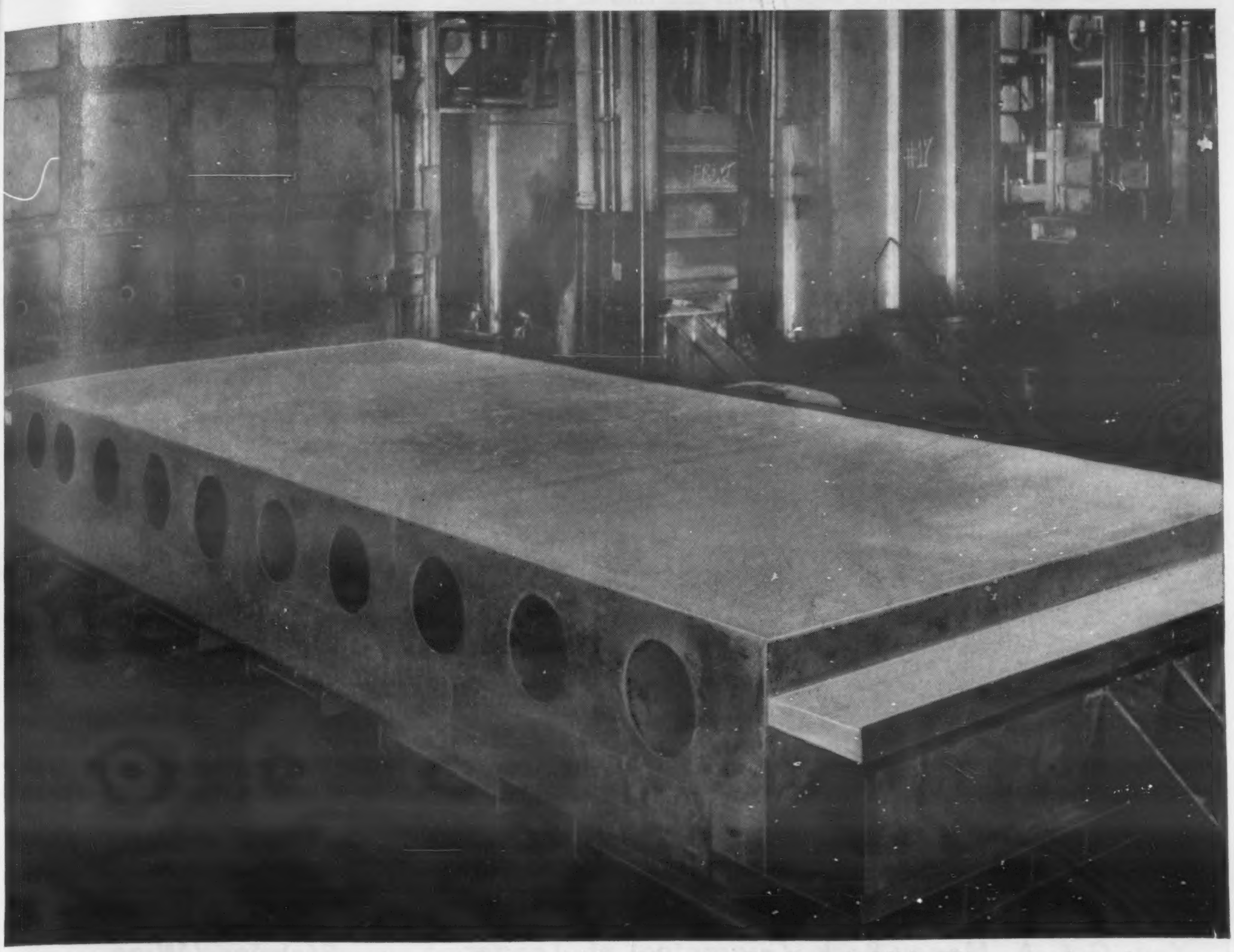
Improved Aluminum Die Cast Finish

A substantial improvement in the finish of aluminum die castings as they come from the die may increase the market for aluminum die castings considerably. Developed by the Aluminum Co. of America, the production and process advances provide a hardware class finish on die cast parts for the first time without requiring additional finishing steps.

The improved finish is expected to remove one of the chief obstacles to widespread use of chromium plated aluminum die castings. Other mechanical and chemical finishes are also improved by the superior finish of the die cast parts. Conventional die cast aluminum die castings require several additional finishing operations before chromium plating is possible. The improved finish can be plated with only a little more effort than is required for zinc. The better die cast finish makes possible a full range of colors in the alumilite process and parts can be buffed to a high polish.

Steel Capacity Grew In 1954

Despite a yearly operating average of only 71% of capacity in 1954, the steel industry of the



REFRACTORY CONCRETE CAR TOP in use at Commercial Steel Treating Co., Detroit, Mich. This car top is made with Zero ZR-13, a Lumnite-base castable produced and marketed by Standard Fuel Engineering Co., Detroit, Mich. For over 15 years this company has used refractory concrete for car tops and furnace door linings.

Why does refractory concrete make the best furnace car top?

EASY TO CAST—TROUBLE-FREE SERVICE! Despite repeated thermal shock and temperatures to 1850° F., Refractory Concrete car tops on this particular job gave more than twice the service life of car tops made with previously used materials.

These durable car tops need less maintenance . . . cut over-all costs. Smooth, one-piece sections form an even, level base for castings. And they are easy to make with Lumnite* calcium-aluminate cement and refractory aggregates.

For added convenience, you can use a Lumnite-base castable mix—Lumnite cement plus aggregates selected for specific temperature and insulation needs. All *you* do is add water, mix and place. Castables are made and distributed by leading refractory manufacturers.

You'll find Refractory Concrete made with Lumnite cement excellent for use wherever heat, corrosion or abrasion are problems. Easy to place—by plastering, pouring or cement gun—and it's ready for use within 24 hours! For more information, write Lumnite Division, Universal Atlas Cement Company (United States Steel Corporation Subsidiary), 100 Park Avenue, New York 17, N. Y.

OFFICES: *Albany, Birmingham, Boston, Chicago, Dayton, Kansas City, Minneapolis, New York, Philadelphia, Pittsburgh, St. Louis, Waco.*

"LUMNITE" is the registered trade-mark of the calcium-aluminate cement manufactured by Universal Atlas Cement Company.

MM-L-100

ATLAS® LUMNITE for INDUSTRIAL CONCRETES

REFRACTORY, INSULATING, OVERNIGHT, CORROSION-RESISTANT

A UNIVERSAL ATLAS PRODUCT

UNITED STATES STEEL HOUR—Televised alternate weeks—See your newspaper for time and station.

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News Digest

continued

United States added steelmaking facilities during the year. The new capacity for the steel industry is 1,497,000 tons more than capacity one year ago, which totaled 124,330,410 net tons. 1955 capacity is 125,828,310 net tons of ingot and steel for casting.

The new additions to the steel industry bring to nearly 34 million tons the growth in capacity in the nine postwar years. The industry's blast furnace capacity went up 1,969,710 tons last year, accounting for the gain. Retirement of obsolete equipment accounts for the discrepancy in the totals. Coke production capacity also rose in 1954, and 95% of blast furnace capacity can now operate without the use of coke from sources outside the steel industry.

The new weekly steel capacity, on which the weekly operating rate is based is 2,413,278 net tons.

Stainless Wins A Round

Chalk up a victory for stainless steel in the race to clad skyscrapers. Stainless has been selected for the world's largest metal clad structure—now a-building near Grand Central in New York City for the Socony Vacuum Co. The 42 story office building will require approximately 750,000 lb of 0.037 in. type 302 chromium nickel stainless steel. Stainless components, in addition to sheathing, include spandrels, window frames, mullions and louvers.

The huge structure, filling an entire city block, will be the first stainless-steel clad building in New York. However, it will not be the first metal-clad building, since several aluminum skyscrapers have been raised in the city during the last two years. The last aluminum building was enclosed with aluminum panels in less than one working day.

Metal clad buildings—both stainless and aluminum—have

News Digest

continued

become increasingly popular due to ease of maintenance, and original construction speed. The lighter weight of the sheathing also saves structural materials.

ASTM Issues Tentatives

The ASTM Administrative Committee on Standards has accepted for publication new Tentative Methods of Test for Silicone Insulating Varnishes (D 1346) on the recommendation of Committee D-9 on Electrical Insulating Materials. These methods cover tests for flexible silicone impregnating and coating varnishes primarily intended to provide electrical, mechanical, and chemical protection for electrical equipment.

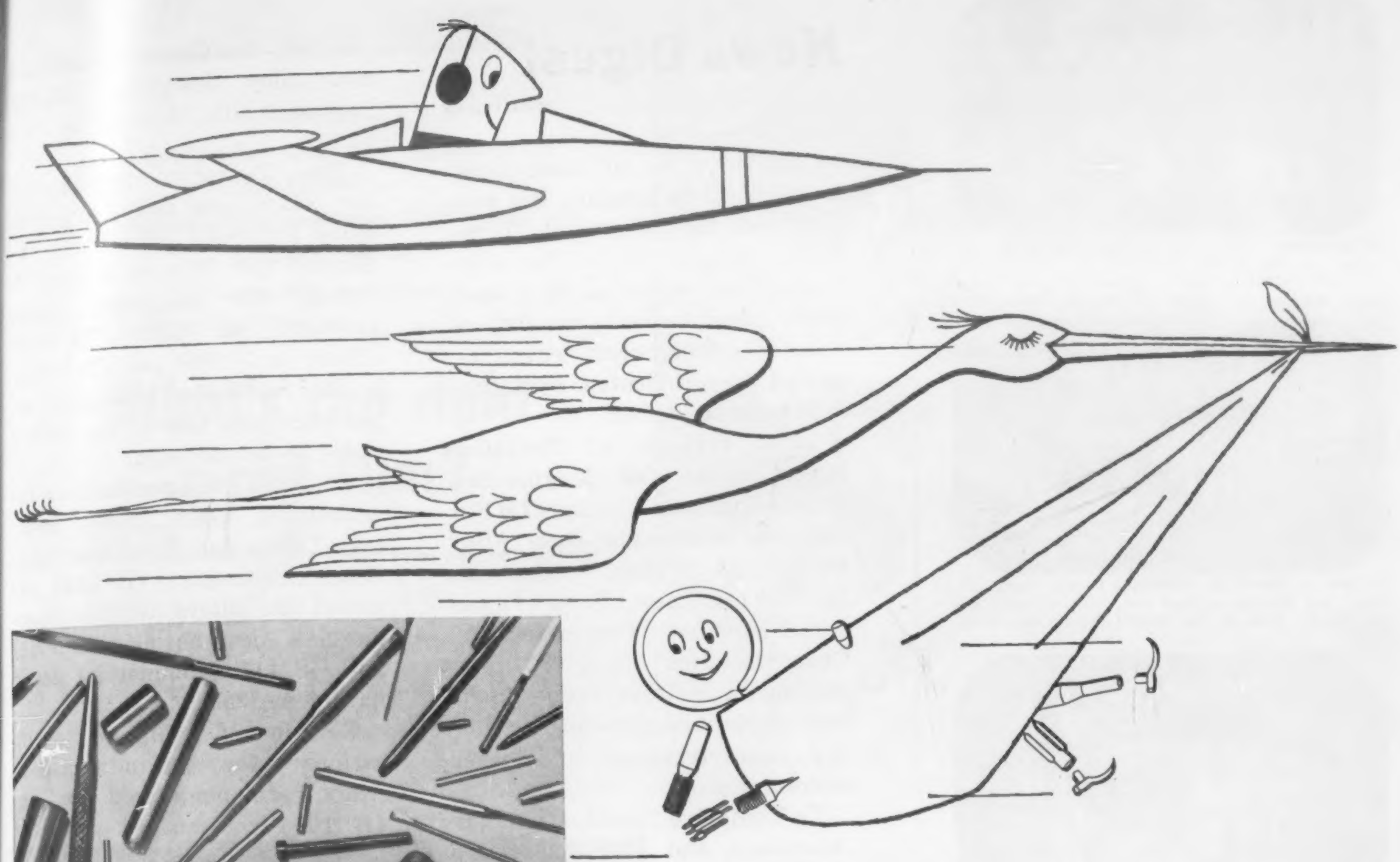
Mica

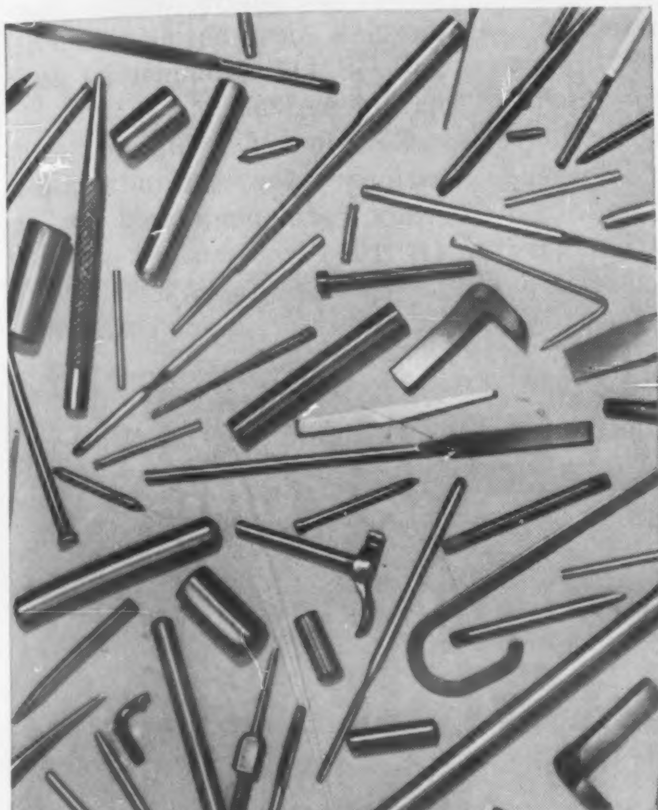
Approval was given also to Committee D-9's recommendation that the Standard Specifications for Natural Block Mica and Mica Films Suitable for Use in Fixed Mica-Dielectric Capacitors (D 748) be reverted to tentative status with revisions. The revisions proposed were for the most part editorial in nature and intended primarily to bring these specifications up to date and make them consistent with the Specifications for Natural Muscovite Mica (D 351). Certain other technical improvements are also included.

Light metals

The Committee also accepted recommendations of Committee B-7 on Light Metals and Alloys, Cast and Wrought for one new tentative recommended practice and the revision of eight existing tentative specifications.

The Tentative Recommended Practice for Temper Designation of Light Metals and Alloys, Cast and Wrought (B 296) is an explanation of the system for designated tempers which are used in the specifications under the jurisdictions of Committee B-7. The designations are based





News Digest

continued

on the sequence of basic treatments used to produce the temper and for all metal forms, except ingot, follow the alloy designation separated by a dash. Basic designations consist of letters; subdivisions where required are indicated by digits following the letter.

In a revision of Tentative Specifications for Magnesium-Base Alloy Sand Castings (B 80) and for Magnesium-Base Alloy Permanent Mold Castings (B 199) a new Table IV is added entitled "Properties and Characteristics" to give information on melting ranges, pattern shrinkage allowance, foundry characteristics, and other characteristics.

To Tentative Specifications for Aluminum and Aluminum-Alloy Sheet and Plate for Pressure Vessel Applications (B 178) and Tentative Specifications for Aluminum-Alloy Sheet and Plate (B 209) the Committee added a new alloy designated GM40A (commercially known as AA 5086).

The Tentative Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, and Shapes (B 221) is revised to change the minimum tensile strength for GS10A-T6 from 32,000 to 30,000 psi. The committee found that production experience had shown the former value to be too high.

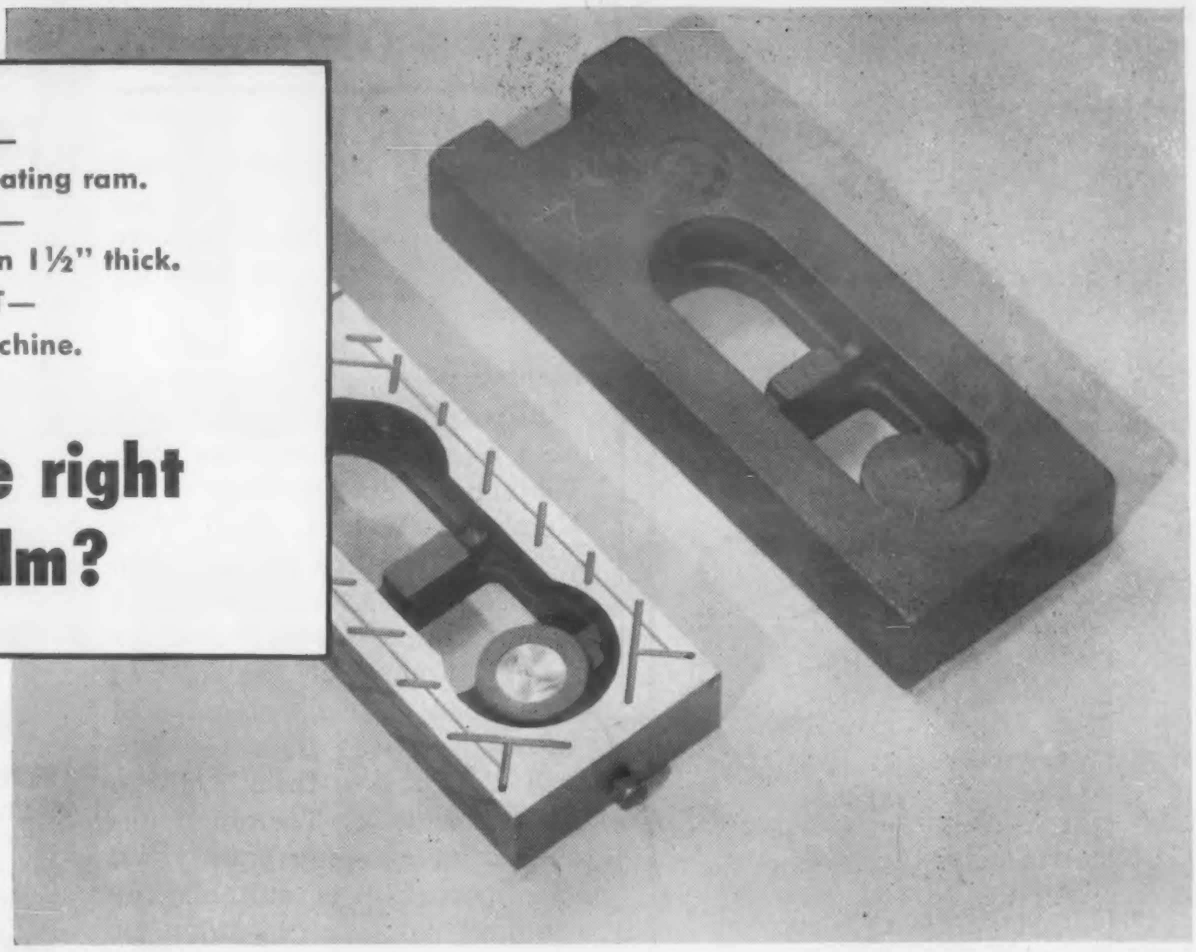
To Tentative Specifications for Aluminum Alloy Drawn Seamless Tubes for Condensers and Heat Exchangers (B 234) are added the alloys GS11A (commercial designation AA6061) and GS 11C (commercial designation AA6062).

Revision of Tentative Specifications for Aluminum-Base Alloy Permanent Mold Castings (B 108) consists of adding a new temper for Alloy ZG42A, a change that reflects current commercial practice.

The Tentative Specifications for Aluminum-Base Alloy Sand

PRODUCT—
Casting for reciprocating ram.
MATERIAL—
High-strength cast iron 1½" thick.
EQUIPMENT—
220 kv x-ray machine.

What's the right x-ray film?



KODAK INDUSTRIAL X-RAY FILM, TYPE K

This casting, worth about $2, is headed for machining, heat treating and scraping worth $375. It's no time to take a chance on hidden faults.

So the radiographer checks each casting and discards the unsound.

For these radiographs he uses 220 kv at a distance of 40 inches, lead screens, and Kodak Industrial X-ray Film, Type K—the right choice for this thickness of iron and x-ray equipment.

THERE'S A RIGHT FILM FOR EVERY PROBLEM

Whatever your radiographic problem, you'll find the best means of solving it in one of Kodak's four types of industrial x-ray film. This choice provides the means to check castings and welds efficiently, offers optimum results with varying alloys, thicknesses and radiographic sources.

Type K—has medium contrast with high speed. Designed for gamma ray and x-ray work where highest possible speed is needed at available kilovoltage, without use of calcium tungstate screens.

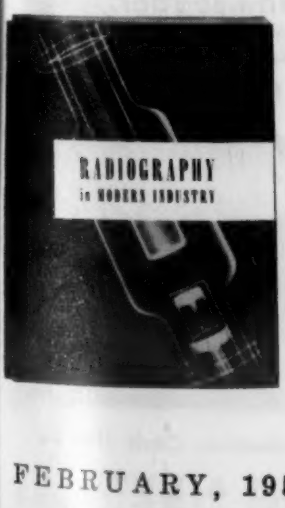
Type A—has high contrast and fine graininess with adequate speed for study of light alloys at low voltage and for examining heavy parts at intermediate and high voltages. Used direct or with lead-foil screens.

Type F—provides the highest available speed and contrast when exposed with calcium tungstate intensifying screens. Has wide latitude with either x-rays or gamma rays when exposed directly or with lead screens.

Type M—provides maximum radiographic sensitivity, with direct exposure or lead-foil screens. It has extra-fine grain and, though speed is less than Type A, it is adequate for light alloys at average kilovoltages and for much million- and multi-million-volt work.

EASTMAN KODAK COMPANY
X-ray Division • Rochester 4, N. Y.

Radiography...another important function of photography



RADIOGRAPHY IN MODERN INDUSTRY

A wealth of invaluable data on radiographic principles, practice, and technics. Profusely illustrated with photographs, colorful drawings, diagrams, and charts. Get a copy from your local x-ray dealer—price, $3.

Kodak
TRADE-MARK

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Castings (B 26) were revised by the addition of a new temper for alloy ZG42A, and a change in the yield strength of alloy ZG61A.

Welded pipe

In response to a request from ASA Sectional Committee B31, Tentative Specifications for Metal-Arc Welded Steel Pipe for High-Pressure Transmission Service (A 381) were developed to fill a definite need. They cover straight seam double submerged arc-welded steel pipe 16 in. and larger in outside diameter, with wall thicknesses from 5/16 to 1½ in. inclusive. The pipe is intended for carrying liquid, gas, or vapor, and is suitable for bending, flanging (vanstoning), corrugating, and similar operations. The Sectional Committee hopes to refer to these specifications in the next revision of the Code for Pressure Piping.

Stronger Polyethylene With Carbon Black

Higher loadings of carbon black increase the bursting strength of polyethylene pipe significantly, according to an applications research project nearing completion.

Acheson Dispersed Pigments Co. of Philadelphia announced that preliminary results of tests indicate that polythylene pipe is sufficiently strengthened by higher loadings of carbon black to withstand pressures in applications now requiring steel pipe. The fact that carbon black is used to strengthen rubber polymers led the company to the idea that higher loadings might improve the burst strength of polyethylene.

The testing program is not yet complete, and Acheson intends to publish a complete report of their findings as soon as the program is finished. The test program was carried out with the cooperation of the Special Blacks Div. of Godfrey L. Cabot Inc., Boston, Mass.

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3rd Welding Show In Kansas City

The American Welding Society will produce its third annual Welding Show at the Municipal Auditorium, Kansas City, Mo., June 8 to 10, inclusive. The show will be the first national heavy industry exposition ever to be staged in Kansas City.

Concurrent with the show, from June 7 to 10, the society will conduct its annual Spring Technical Meeting in the same city.

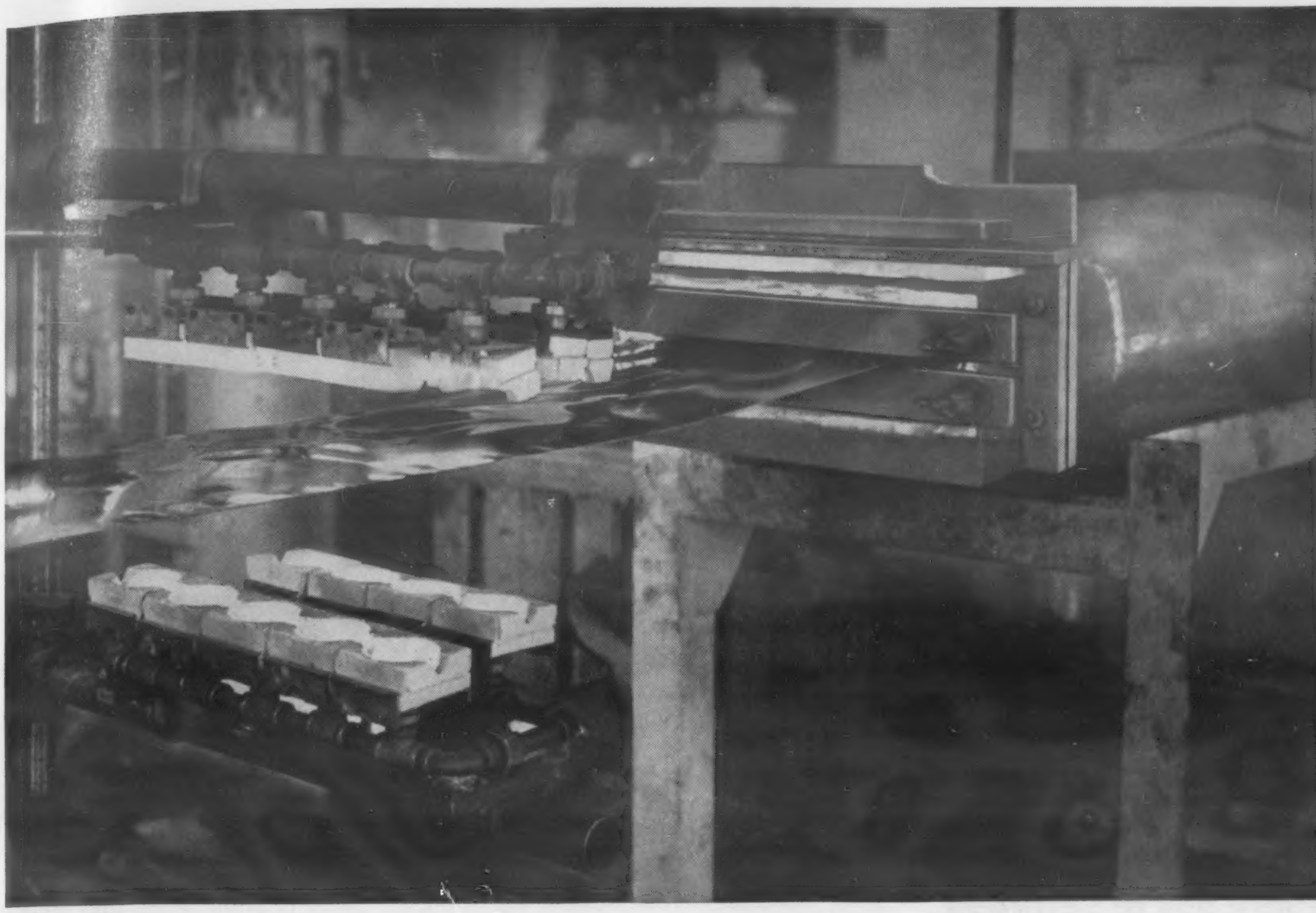
Joseph G. McGrath, national secretary, said, "The decision to take the show to Kansas City is in line with the society's program to extend the knowledge of the science to all American industry. New developments in welding have been so numerous in recent years that many production and maintenance executives have found it difficult to keep pace with them.

"An exposition, by demonstrating the equipment under simulated factory conditions, is a great teaching medium. Kansas City, the hub of the Mid-Continent, is only one day's travel from most industrial centers in the country, and is ideal from the standpoint of extending the frontiers of our knowledge. The expanding industrial areas of the South, the Southwest and the West will profit most by producing our exposition in Kansas City." he said.

Corrosion Test Under Development

Within the next year or so, a better accelerated corrosion test for copper-nickel-chromium and chromium flashed stainless steel should be forthcoming, according to D. M. Bigge, head of Chrysler Corp. Engineering Division's Chemical Dept.

Mr. Bigge said that the salt spray chamber has been shown to be insufficient as a testing technique not only in that it does



Inconel averages nine months service in this D-shaped muffle used in gas-fired furnaces to continuously anneal strip at Somers Brass Company, Waterbury, Conn. Previous materials failed in weeks.

In goes Inconel... *Up* goes life of muffles

Somers Brass *finds way to offset triple attack on muffles where metal temperatures go up to 2200° F.*

This was a tough one...

Temperatures running as high as 2200°F.... super-hot corrosive combustion gases outside the muffle... carbon rollers inside, plus hydrogen (from the cracked ammonia) to cause embrittlement.

Under such a three way attack, muffles cracked in a matter of weeks, destroying the integrity of the controlled atmosphere, spoiling the finish on strip being annealed.

With every muffle material Somers Brass tried, it was the same story... until they came to Inconel®. Inconel is giving them nine full months of service on the average, a big boost in production economy.

Inconel steps up life in 3 ways

Inconel retains usable strength up to 2200°F. Inconel resists carburization and high temperature corrosion. Inconel withstands severe thermal stressing without cracking or spalling.

Do you need these properties, too?

If so, consider Inconel. It's an easy material to fabricate and keep in repair. Furthermore, there's an Inco booklet that suggests many ways to use Inconel effectively... "Keeping Operating Costs Down as Temperatures Go Up." Write for a copy today.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

Inconel

INCO TRADE MARK **NICKEL ALLOYS**

...for long life at high temperatures

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not provide reproducible results in different equipment, but that it does not provide results that are at all comparable to actual environmental conditions, particularly industrial atmospheres. He cited, as an example, that chromium flashed stainless steel does not show up as well in salt spray tests as copper-nickel-chromium. But exposed to industrial atmospheres, the reverse is true.

Bigge said that costly examples of the corrosive effect of industrial air have occurred during the last few winters in Detroit. During one extended period of high humidity, snow, sleet and industrial gas concentration, the chromium plated bumpers of several thousand automobiles stored in outdoor lots had to be replaced. Industrial acids in sleet, combined with salty road splash, abrasion, and freeze-melt cycling will ruin most chromium finishes in almost nothing flat.

Bigge is confident that a new accelerated test that will incorporate the effects of both marine and industrial atmospheres should enable researchers to come up with better protective coatings. However, such a test can't be designed until more is known about industrial atmospheres.

The first task facing test designers is to find out what kind of damage automobile finishes are exposed to. Secondly, there must be an accelerated test that reproduces the damage. Presently, Mr. Bigge and the Electroplater's Society have enlisted a large fleet of Detroit taxicabs to do guinea pig work. Metal plates, the size of license plates, have been taper-plated and attached to the front bumper of the taxi cabs (luckily, there are no front-end license plates in Michigan). Since the cabs are used every day, and if not, records are available to show when they were out of service, test plates will show

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what happens to chromium during various lengths of time and under recorded weather conditions. Such data will be invaluable in designing a standard accelerated test.

Bigge hopes that the data collected will be used to do more than design a test and provide a better coating. The taxi plate and static industrial atmosphere exposure plates will supply data for state, municipal and federal groups on air pollution and on the effect of excessive salting of streets during ice and snow conditions.

The best way to keep an automobile shiny, Bigge maintains, is to get at the source and clean up the air and the streets. Such an accomplishment would far overshadow the benefits accruing from better finishes.

Mach 3.5 Seen as Top Flight Speed

Research on materials to withstand the effects of high flight speeds lags far behind the development of airframes and power plants capable of pushing speeds well into the present thermal barrier, according to papers delivered at the annual meeting of the ASME.

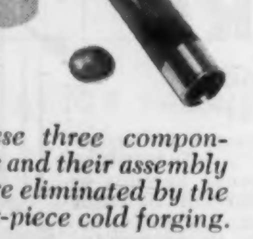
The thermal barrier, unlike the sound barrier, cannot be "passed." It simply gets hotter in a geometric ratio to speed. Among the more startling facts: at Mach 5, or five times the speed of sound, aluminum melts from skin friction; at Mach 6, most steels melt. Both materials lose strength at far lower speeds. Present top speeds of experimental piloted aircraft that have been released by the Air Force are pushing close to Mach 2—and even at this speed aluminum loses its strength and it is necessary to go to stainless steel and other high-strength, heat-resistant materials. Even these materials are only adequate for short periods of high speed flight and

HUNTER DOUGLAS ONE-PIECE COLD FORGINGS

replace 3 piece unit, eliminate assembly, solve gas leakage problems!

A typical example of how Hunter Douglas cold forgings simplify everyday design problems

A most critical requirement in the production of an ordnance component was a perfect seal against the escape of high pressure gases. Fabrication by conventional procedures involved the assembly of three separate pieces—a screw machine part turned from bar stock and bored from each end; a separate sleeve machined from tubing, and a stamped Welsh plug. The three parts were unitized by expanding the Welsh plug within the sleeve, forcing walls into a machined groove within the head.



These three components and their assembly were eliminated by the one-piece cold forging.

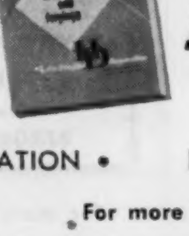
To simplify the design, insure leak-proof construction and eliminate costly machining and assembly time, Hunter Douglas engineers suggested a cold forging from HD-11-T6, a high strength aluminum alloy.

All internal and external diameters of the cold forged component are now formed in a single, instantaneous press operation. No joints exist to cause leakage, consequently rejects are negligible. The cold forging, being highly stressed, easily withstands bursting pressures of 5500 psi without distortion. With its remarkable simplification in design, the cold forging requires fewer machining operations, thus saving both time and unnecessary metal waste.

Hunter Douglas Cold Forgings can be mass-produced in any required numbers and to cover a tremendous range of design requirements. If your components require *walls of zero draft, high physical properties, employ tubular shapes with or without a closed end, and must meet close dimensional tolerances,* HUNTER DOUGLAS COLD FORGINGS may provide the answer. Our engineers will give you a prompt analysis upon submission of a blueprint or sample part.

Hunter Douglas Cold Forgings cover a multitude of needs. Note wide variation in part geometry. Many complex designs formerly considered impossible to produce by cold forging now respond to new techniques developed at Hunter Douglas.

DESIGNERS:
If you want to know more about Hunter Douglas Cold Forgings write on your company letterhead for this free 40 page book, now on the press!



Hunter Douglas Corporation

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present fatigue problems.

Engineers agree that sooner or later aircraft will have to be designed to carry loads while hot, —hot being anywhere from 200 to 1600 F. Dr. George Gerard, of New York University, summarizing engineering opinion on thermal flight, said that optimists believe that the thermal barrier may be dodged by restricting flight speeds at low altitudes and flying very fast at altitudes where air density—and friction —is practically zero. More pessimistic designers think that this solution is not practical. Dr. Gerard, in describing results of NYU's engineering research, foresees an upper limit of about Mach 3.5 for aircraft speeds with present materials. At this speed, which would generate temperatures of 800 F, the structure necessary to withstand the high stresses and temperatures would make the aircraft impractical aerodynamically. A fighter might weigh as much as a current heavy bomber.

An alternative for heat resistant materials in non-piloted aircraft would be to design the equipment so that part of it could melt. As the missile is a one shot aircraft, it is not necessary to have it the same on arrival as on departure, as long as control can be maintained for the short flying lifetime.

Harold Adams, of Douglas Aircraft, suggested two design approaches—to design for high temperature endurance, and to use some sort of cooling on conventional designs. While the first course presents insuperable obstacles at the present time, the Douglas engineer claimed, there are several possibilities for the second course. Cooling by air cycle systems, heat sinks utilizing fuel supplies, transpiration cooling by water evaporation, and refrigeration all hold some promise of extending the speed of flight further into the barrier.

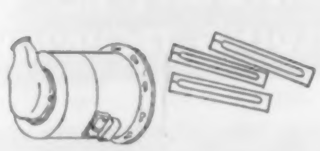
Many engineers in the field of

TAYLOR
Laminated Plastics
Vulcanized Fibre

Shop Talk

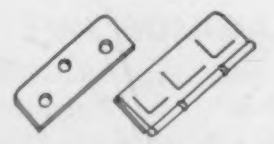
TAYLOR FIBRE CO.
Plants in Norristown, Pa. and La Verne, Calif.

Tips for designers

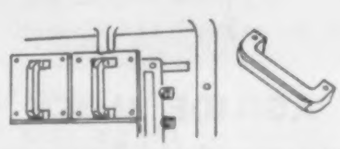


High temperatures in an aircraft generator posed a tough problem for rotor insulation . . . solved by Taylor Silicone Laminate.

Television tuner uses a shaft made of Taylor polyester glass rod . . . a strong material with excellent insulating qualities.



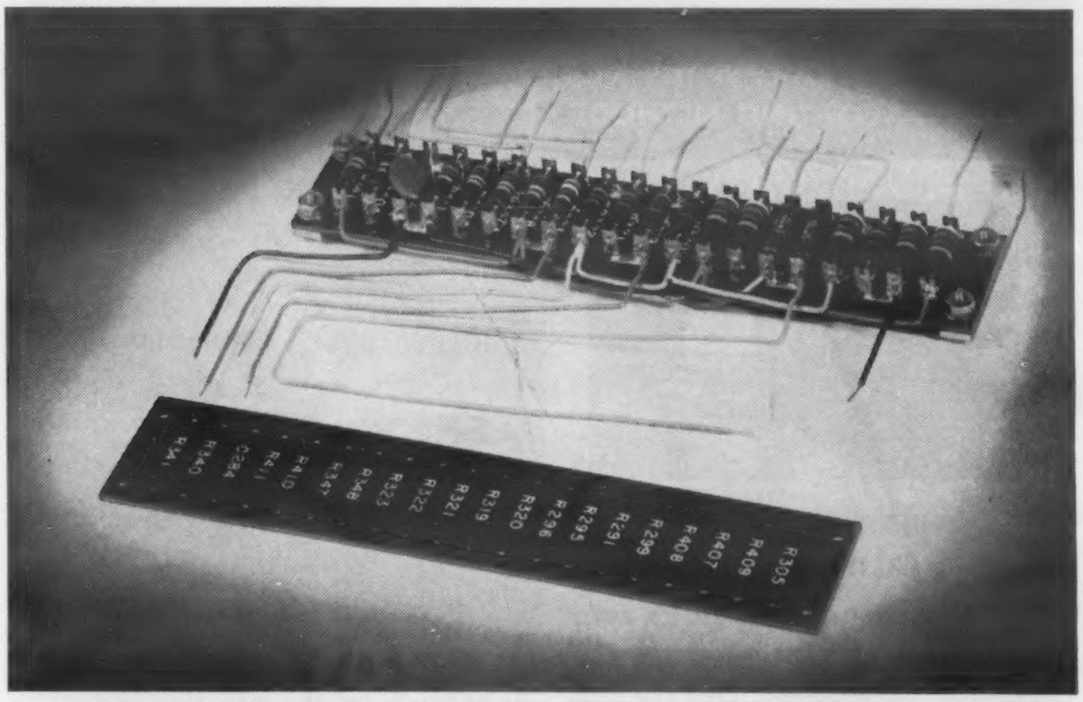
Refrigerator doors are hung with hinge spacers of Taylor Super White Vulcanized Fibre . . . tough, smooth, abrasion-resistant and readily formed.



Handles for heavy-duty fuse boxes are made of Taylor melamine laminate for resistance to arcs, corrosion . . . and for high mechanical strength.

TAYLOR FABRICATING FACILITIES

Your production problems can often be simplified . . . schedules safeguarded . . . inventory headaches cured . . . and overall costs reduced by having Taylor fabricate finished parts of vulcanized fibre and laminates to your specifications. Efficient, modern facilities are ready to serve you. Write to Taylor about your specific requirements.



Terminal boards for Hewlett-Packard high-precision electronic instrument circuit are made of Taylor XXXP-301 laminate... chosen for its excellent, stable insulating qualities.

Unique hot punch laminates—*set new performance standards*

Taylor's new "300" series of paper base laminates were developed specifically to meet the stringent demands of modern electronic products. These hot-punch materials now make it possible for you to get premium physical and electrical properties . . . without premium price.

These new Taylor materials are unique. They're uniform all the way through . . . no surface overlay of resin. Their superior performance will add to the value of your products. And their excellent fabricating qualities will give you substantial savings in production. Equally important, you are always sure of these properties in every shipment, thanks to Taylor's methods of manufacture and strict laboratory control in each phase of processing.

A wide selection of grades of the new laminates have been developed to fill varied requirements of electronics manufacturers:

XXXP-301—the ultimate in electrical properties. Unusually high insulation resistance under all climatic conditions . . . low water absorption . . . excellent punching and staking . . . phenomenal recovery. Premium performance at standard price.

XXP-351—a high-grade laminate second only to XXXP-301, with closely comparable characteristics at a lower price.

Grade 353—a quality laminate with outstanding electrical and physical properties . . . priced for economy.

Grade 354—a laminate that's especially easy to fabricate. Good stability, low water absorption, and economical price.

Grade 381—flame retardant with high arc resistance.

Plan to take advantage of these new laminates in the products you are now designing. Write to Taylor for full data, and for a consultation by a Taylor engineer.

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military aircraft are beginning to think more and more in terms of limited lifetimes for piloted aircraft as well as missiles. An airframe certified for a maximum life of, say, 100 hr, would solve many fatigue problems, this group believes, and could be produced in greater volume to offset shorter lifetime. A British turbojet power plant, which develops the highest thrust per pound of any engine yet produced, has a lifetime of only 10 hr, could be used in missiles or in interceptor or parasite-type piloted fighter aircraft.

SPI to Survey Fire Hazards

The Society of the Plastics Industry has set up a Committee on Fire Prevention. The committee will develop material for a manual on fire prevention as it applies to the plastics industry and its products. The manual will serve to acquaint officials of municipalities and other regulatory bodies with what does and does not constitute a fire hazard in the plastics industry. It will also contains do's and don'ts regarding good housekeeping and safety in plastics plants.

The SPI feels that in the past fire hazards in the plastics field have been magnified unduly and it is felt that the publication and assimilation of instructive material on fire prevention as related to plastics will help to clarify the industry's position.

Twenty-five companies producing or fabricating plastics are engaged in the project, which has the approval of the Board of Fire Underwriters.

Correction

Armco Steel Corp. was inadvertently omitted from a list of suppliers in our manual on "Clad and Precoated Metals".

Armco is an important supplier of hot dip zinc-coated steel sheet and strip under the Zincgrip tradename, and should have been listed in the table on p. 127 of our December issue.

CORNING GLASS BULLETIN

FOR PRODUCT DESIGNERS

Three problems . . . one "E-C" answer

How would *you* shield a complex, static-sensitive hunk of machinery from stray electric charges and still keep its innards open to inspection?

That's a problem IBM faced in designing their now-famous electronic calculator—and solved with E-C glass. Ordinary glass wouldn't do. It wouldn't keep electrons in line. Metal would have been ideal for the shielding job, but not so good for seeing through. E-C coated glass does the one and allows the other.

E-C coated glass is a PYREX brand glass. It stands up well under physical and thermal shocks. But its main claim to fame is the transparent, conductive coating (about 20-millionths inch thin) that's permanently bonded to one side of it. It's this coating that keeps static charges from gumming up IBM's complex circuits busy calculating.

But there's more to E-C coated glass than shunting off unwanted electrical charges. Run a current through it and you've got a heating element that gives forth with a *uniform*, dry, controllable, radiant heat, up to 350° C. The emphasis is on *uniform*—no furrows of heat with coolth in between; no dead spots.

This uniform heating element is already at work in medical sterilizers, drying ovens, room heaters, chicken brooders.

And here's a third kind of application. Turn an E-C panel around and you have a highly efficient heat *reflector*. A well-known steel company protects shear pulpit operators from the fiery heat of billets in process with transparent E-C panels.

Product or process—the potential of E-C coated glass hardly seems tapped. We've learned a lot about it that we'd be glad to share with you.

Multi-aptitude problem—So many folks have exhibited so much interest in the ability of our VYCOR brand 96% silica glasses to survive, unscathed, wide temperature variations (quick switches from below freezing to 1800° F. or higher) that its other attractions for a designer may fall into oblivion.

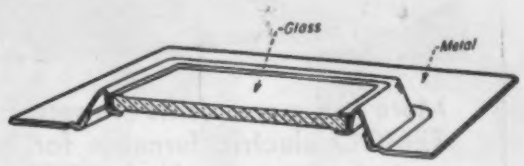
This we don't want to happen, and you might not either. Actually, there are seven VYCOR brand glasses available today—all high silica, but each compounded to develop specific aptitudes. Glass 7911, for example, we control especially for uniform, high transmittance of short-wave ultraviolet. It has notably high electrical resistivity, too, and low power loss. Glass 7910 meets germicidal lamp requirements for transmitting ultraviolet at 254 millimicrons. Glass 7950 will absorb most of the visible light from a tungsten filament (2700° K.), but let infrared radiation pass freely.

Our brand new bulletin B-91, "VYCOR brand Industrial Glassware by Corning," completes the story with all the basic data we can put in print about all seven VYCOR brand glasses—with curves and illustrations. It just might stimulate an application idea or two for you. Would you like a copy?

On becoming attached—Nothing personal—just a first step, we hope, toward informing you about ways of attaching glass to metal.

We've found a lot of our customers have more than a passing interest in this subject. We do too, as you might imagine, what with some 50,000-odd formulas for glass hankering to be put to new uses.

Below, for example, is *one* of the "recommended methods of attaching glass to metal structures"—from a bulletin of that name!



This particular one is a soldered joint between glass and metal. The glass panel has a metallized edge to accommodate soldering to the metal frame.

The brochure (actually an editorial reprint from "Product Engineering") shows some 16 other types, including threaded joints, pressure-tight joints, spun-metal joints and electrical connections. We'd be delighted to send you a copy.

* * * *

Which brings us to our basic theme—glass itself. That's a world amazing even to those of us who spend most of our waking hours exploring its apparently endless boundaries.

What progress we've made to date, mostly working with folks who have materials problems to solve, is spelled out in a little volume we've offered before and offer again in light of the sustained demand for it. A copy of "Glass and You" will show how this centuries-old material fits 20th century technology. It's a good starting point for getting acquainted. May we send you a copy?

Corning means research in Glass

CORNING GLASS WORKS, 12-2 Crystal Street, Corning, N.Y.

Please send me the information checked below:

☐ E-C glass; ☐ "VYCOR brand Industrial Glassware by Corning"; ☐ "Methods of attaching glass to metal structures"; ☐ "Glass and You"; ☐ Send a representative to call on me.

Name__________ Title__________

Company__________

Address__________

City__________ Zone______ State______

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